01 SOLID FUELS

Sources, winning, properties

08/01842 An analytical model of the mechanical properties of bulk coal under confined stress

Wang, G. X. *et al. Fuel*, 2007, 86, (12–13), 1873–1884.

This paper presents the development of an analytical model, which can be used to relate the structural parameters of coal to its mechanical properties such as elastic modulus and Poisson's ratio under a confined stress condition. This model is developed primarily to support process modelling of coalbed methane (CBM) or CO_2-enhanced CBM (ECBM) recovery from coal seam. It applied an innovative approach by which stresses acting on and strains occurring in coal are successively combined in rectangular coordinates, leading to the aggregated mechanical constants. These mechanical properties represent important information for improving CBM/ECBM simulations and incorporating within these considerations of directional permeability. The model, consisting of constitutive equations which implement a mechanically consistent stress–strains correlation, can be used as a generalized tool to study the mechanical and fluid behaviours of coal composites. An example using the model to predict the stress–strain correlation of coal under triaxial confined stress by accounting for the elastic and brittle (non-elastic) deformations is discussed. The result shows a good agreement between the prediction and the experimental measurement.

08/01843 Analyses of mild hydrogenation products of coals treated with zinc and butyl iodide

Yoneyama, Y. *et al. Fuel Processing Technology*, 2008, 89, (4), 460–466.

Butylation using zinc and butyl iodide under mild conditions (130 °C and atmospheric pressure) is an effective method to convert solid coals to soluble products in poor solvents such as hexane and benzene. Because of mild conditions and high solubility, the butylation of coals is found to be applicable for estimating coal structures. Until now, two typical coals, Taiheiyo and Yubari coals, were converted to hexane soluble products significantly. However they were too heavy to obtain much information on the structure of the original coals. In order to analyse the structural features of the coals butylated with zinc and butyl iodide, the polar mixture (PM) fractions separated from hexane soluble products (HS) from butylated Yubari and Taiheiyo coals were hydrogenated using Adkins catalyst. The HS products of hydrogenated PM fractions were fractionated by gel permeation chromatography (GPC), and the GPC fractions were further analysed. After hydrogenation, structural parameters of HS products separated from PM fractions did not change so much, but molecular weight decreased. The GPC fractions (Fr.1–Fr.7) from both coals had similar high σal (degree of aliphatic chain substitution) as well as low fa (aromaticity) to the original PM fractions. These results indicated that the GPC fractions were highly butylated. Many structural parameters of GPC fractions except for Fr.7 were similar with each other. For Taiheiyo coal, the ring sizes of GPC fractions were 1–2, and similar to those from pyridine soluble products. For Yubari coal they were 2–3, and smaller than those from pyridine soluble product, 4 due to reductive butylation. The ring sizes of the Fr.7 from both coals were as small as one. Because the solvent soluble products were subject to reductive butylation, the naphthenic rings of the fractions seemed to be ruptured by hydrogenation. These findings suggest that high hexane extractability of the coals butylated with zinc and butyl iodide was caused by reductive butylation.

08/01844 Coal petrology of coal seams from the Leão-Butiá Coalfield, Lower Permian of the Paraná Basin, Brazil – implications for coal facies interpretations

Silva, M. B. *et al. International Journal of Coal Geology*, 2008, 73, (3–4), 331–358.

In the Leão-Butiá Coalfield, Rio Grande do Sul the coal seams occur in the Rio Bonito Formation, Guatá Group, Tubarão Supergroup of the Paraná Basin, Brazil and are of Permian (Artinskian–Kungurian) age. This study is the first detailed investigation on the coal petrographic characterization of the coal-bearing sequence in relation to the depositional settings of the precursor mires, both in terms of whole seam characterization and in-seam variations. The study is based on the analyses of nine coal seams (I2, CI, L4, L3, L2, L1, S3, S2, S1), which were selected from core of borehole D-193, Leão-Butiá and represent the entire coal-bearing sequence. The interpretation of coal facies and depositional environment is based on lithotype, maceral and microlithotype analyses using different facies-critical petrographic indices, which were displayed in coal facies diagrams. The seams are characterized by the predominance of dull lithotypes (dull, banded dull). The dullness of the coal is attributed to relatively high mineral matter, inertinite and liptinite contents. The petrographic composition is dominated by vitrinite (28–70 vol.% mmf) and inertinite (>30 vol.% mmf) groups. Liptinite contents range from 7 to 30 vol.% (mmf) and mineral matter from 4–30 vol.%. Microlithotypes associations are dominated by vitrite, duroclarite, carbominerite and inertite. It is suggested that the observed vertical variations in petrographic characteristics (lithotypes, microlithotypes, macerals, vitrinite reflectance) were controlled by groundwater level fluctuations in the ancient mires due to different accommodation/peat accumulation rates. Correlation of the borehole strata with the general sequence-stratigraphical setting suggests that the alluvial fan system and the coal-bearing mudstone succession are linked to a late transgressive systems tract of sequence 2. Based on average compositional values obtained from coal facies diagrams, a deposition in a limno-telmatic to limnic coal facies is suggested.

08/01845 Geochemistry of trace elements in Çan coal (Miocene), Çanakkale, Turkey

Gürdal, G. *International Journal of Coal Geology*, 2008, 74, (1), 28–40.

This study focuses on the geochemistry of trace elements and the coal quality parameters of Miocene lignite's from Çan basin. Twelve coal samples have been studied using proximate and ultimate analyses, X-ray powder diffraction, inductively coupled plasma-mass spectrometry, inductively coupled plasma-atomic emission spectrometry, scanning electron microscopy with energy-dispersive X-ray microanalysis and organic petrographic analyses. The Çan coals on an air-dried basis are characterized by broad variation of ash (ranging from 4.42% to 36.72%), high total sulfur contents (up to 8.10%) and high gross calorific values (3870–6612 kcal/kg). The mineral matter of the studied coal samples is made up of quartz, pyrite, clay minerals and gypsum. Major elements correlate positively with dry ash contents demonstrating an association with inorganic constituents. For 20 trace elements, including As, B, Ba, Be, Cd, Cu, Co, F, Hg, Mo, Ni, Pb, Sb, Se, Sn, Th, Tl, U, V and Zn received much attention due to environmental and human health concerns. Based on statistical analyses, most of the trace elements, except for Ba, Mo, Se and U, show an affinity to ash content. Elements including As, Cu, Co and Hg appear to be associated with pyrite. The concentrations of the trace elements are within the range of world coal average. However, the V content is higher than the world coal value and some volatile elements such as As, B and U are slightly enriched in some coal samples.

08/01846 Identifying spatial heterogeneity of coal resource quality in a multilayer coal deposit by multivariate geostatistics

Nur Heriawan, M. and Koike, K. *International Journal of Coal Geology*, 2008, 73, (3–4), 307–330.

This study presents a new geostatistical approach to characterization of the geometry and quality of a multilayer coal deposit using the data of seam thickness as a geometric property and the contents of ash, sodium, total sulfur, and the heating value as quality properties. A coal deposit in East Kalimantan (Borneo), Indonesia, which has a synclinal geological structure, was chosen as the study site. Semivariogram analysis clarified the strong dependence of heating value on ash content in the top and bottom parts of each seam and the existence of a strong correlation with sodium content over the sub-seams in the same location. The correlations between the geometry and quality of the seams were generally weak. A linear coregionalization model was used to derive the spatial correlation coefficients of two variables at each scale component from the single- and cross-semivariogram matrices. Because the data were correlated spatially in the same seam or over different seams, multivariate techniques (ordinary cokriging and factorial cokriging) were mainly used and the resultant spatial estimates were compared to those derived using a univariate technique (ordinary kriging). A factorial cokriging was effective to decompose the spatial correlation structures with different scales. Another important characteristic was that the sodium content shows distinct segregation: the low zones are concentrated near the boundary of the sedimentary basin, while the high zones are concentrated in the central part. The main component of sodium originates from the abundance of saline water. Therefore, it can be inferred that seawater had stronger effects on the coal depositional process in the central basin than in the border part. The geostatistical modelling results suggest that the thicknesses of all the major seams were controlled by the syncline structure, while the coal qualities chiefly were originated from the coal depositional and diagenetic processes.

08/01847 Ignition characteristics of coal blends in an entrained flow furnace

Faúndez, J. *et al. Fuel*, 2007, 86, (14), 2076–2080.

Ignition tests were carried out on blends of three coals of different rank – subbituminous, high volatile and low volatile bituminous – in two entrained flow reactors. The ignition temperatures were determined from the gas evolution profiles (CO, CO_2, NO, O_2), while the mechanism of ignition was elucidated from these profiles and corroborated by high-speed video recording. Under the experimental conditions of high carbon loading, clear interactive effects were observed for all the blends. Ignition of the lower rank coals (subbituminous, high volatile bituminous) enhanced the ignition of the higher rank coal (low volatile bituminous) in the blends. The ignition temperatures of the blends of the low rank coals (subbituminous–high volatile bituminous) were additive. However, for the rest of the blends the ignition temperatures were always closer to the lower rank coal in the blend.

08/01848 Kinetic study on solvent swelling of coal particles

Murata, S. *et al. Fuel Processing Technology*, 2008, 89, (4), 434–439.
Solvent swelling experiments of coal particles of Taiheiyo and Witbank coals in pyridine at 15–50°C were conducted by using an orthogonal microscope coupled with an image analysis system and the newly prepared temperature-controlled cell. Two kinetic parameters, n (a number that crudely indicates the nature of the solvent diffusion) and k (a rate constant), were calculated based on time profile of volumetric swelling ratio. The authors examined the correlation between these parameters and volumetric swelling ratios, to find that there was linear correlation between n and $\ln(1/k)$. By using the proportional constant, the authors calculated activation energy of the swelling of both coals. The energy changed with respect to each particle. Average values were 71 kJ/mol for Taiheiyo coal and 55 kJ/mol for Witbank coal, these values agree well with the values reported in the literature. The authors also examined the effects of pretreatments of both coals. *O*-Acetylation and pyridine pre-extraction decrease the energies drastically.

08/01849 Radiometric age determination of tonsteins and stratigraphic constraints for the Lower Permian coal succession in southern Paraná Basin, Brazil

Guerra-Sommer, M. *et al. International Journal of Coal Geology*, 2008, 74, (1), 13–27.
Ion microprobe (SHRIMP II) dating of zircons from tonsteins interbedded with coal seams from the Candiota and Faxinal coalfields (Early Permian, Rio Bonito Formation, Paraná Basin, Brazil) is presented. The mean ages obtained (290.6 ± 1.5 Ma) are more precise than previously published intervals. Calibrations of chronostratigraphic data with radiometric ages show that the main coal succession from the southern Basin is constrained to the Middle Sakmarian. The ±2 Ma time interval of deposition supports the hypothesis that the coal-generating process was quite rapid in terms of geological time. In a general context, Faxinal and Candiota coals are assigned, into the *Protohaploxypinus goraiensis* Subzone, besides some paleocological differences evidenced by palynological studies. This bio-interval does not correspond to a consistent palynostratigraphic tool and more accurate biostratigraphic zonation for the Carboniferous–Permian interval must be delineated. The new results have far-reaching significance for correlations of the Basin with sequences of the Argentinian Paganzo Basin (302 ± 6 Ma and 288 ± 7 Ma) and also with the Karoo Basin, with the lowermost Ecca Group (288 ± 3 Ma and 289.6 ± 3.8 Ma). This new evidence supports the presence of an active and widespread Lower Permian explosive volcanic event in western Gondwana, which is interpreted as the same volcanism which produced the Choiyoi Group in western Argentina. According to this correlation the ash-fall source is located about 1400 km to the southwest of their area of deposition.

08/01850 Sinterability enhancement in semicokes obtained by controlled pyrolysis of a petroleum residue

Llorca-Porcel, J. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 163–169.
Self-sintering semicokes were prepared by pyrolysis of an aromatic petroleum residue at 460–480 °C and pressures of 0.1–1.0 MPa. The evolution of gases and thermoplasticity from resultant semicokes were monitored by TGA and TMA, respectively. Sintering behaviour of the semicokes is extremely sensitive to pyrolysis conditions which determine contents of volatile matter and binder phase. Semicokes produced at 1.0 MPa have high volatile contents with excessive plasticity. Changes of temperature and soak time, used to reduce volatile matter contents induce reductions to the plasticity and sintering. A lower pyrolysis pressure has a similar effect. Although the operational window is narrow, heat-treated compacts (2500 °C) can be made with high density ($1.9\,\mathrm{g\,cm^{-2}}$) and bending strengths >75 MPa. Using high-temperature pyrolysis (460 °C) with a post-treatment at 350–400 °C eliminates light components, without decreasing sintering properties. Compacts from these powders also exhibit high density ($1.9\,\mathrm{g\,cm^{-2}}$) with higher bending strengths >90 MPa, comparable or superior to mesocarbon microbeads (MCMB) obtained from the same precursor.

08/01851 Some recent advances in the understanding of the pyrolysis and gasification behaviour of Victorian brown coal

Li, Z.-C. *Fuel*, 2007, 86, (12–13), 1664–1683.
The brown coal in the Latrobe Valley, Victoria, Australia, has many unique structural features and properties. The brown coal has a very low ash yield and contains highly dispersed alkali and alkaline earth metallic (AAEM) species, either as carboxylates forming part of its organic matter or as NaCl dissolved in its moisture. Owing to its unique structural features and properties, the brown coal behaves very differently from many other solid fuels such as biomass, bituminous coals and anthracites. For example, the highly reactive nature of its volatiles, the vulnerable nature of its nascent char and the presence of finely distributed AAEM species mean that the volatile–char interactions, a common phenomenon in all gasifiers, especially in the fluidized-bed gasifiers, would influence almost every aspect of its pyrolysis and gasification behaviour. Some recent progress in the understanding of the pyrolysis and gasification behaviour of Victorian brown coal will be reviewed in this paper. The progress in the fundamental understanding of the pyrolysis and gasification behaviour of Victorian brown coal has laid solid foundation for the further development of advanced gasification technologies for the clean and efficient utilization of this cheap but important resource.

08/01852 The calculation of the chemical exergies of coal-based fuels by using the higher heating values

Bilgen, S. and Kaygusuz, K. *Applied Energy*, 2008, 85, (8), 776–785.
This paper demonstrates the application of exergy to gain a better understanding of coal properties, especially chemical exergy and specific chemical exergy. In this study, a BASIC computer program was used to calculation of the chemical exergies of the coal-based fuels. Calculations showed that the chemical composition of the coal influences strongly the values of the chemical exergy. The exergy value of a coal is closely related to the H:C and O:C ratios. High proportions of hydrogen and/or oxygen, compared to carbon, generally reduce the exergy value of the coal. High contents of the moisture and/or the ash cause to low values of the chemical exergy. The aim of this paper is to calculate the chemical exergy of coals by using equations given in the literature and to detect and to evaluate quantitatively the effect of irreversible phenomena increased the thermodynamic imperfection of the processes. In this paper, the calculated exergy values of the fuels will be useful for energy experts studied in the coal mining area and coal-fired powerplants.

Preparation

08/01853 Demineralization of a UK bituminous coal using HF and ferric ions

Wu, Z. and Steel, K. M. *Fuel*, 2007, 86, (14), 2194–2200.
A UK bituminous coal has been used to study demineralization by two-stage chemical leaching. The first-stage uses hydrofluoric acid (HF) at 65 °C and reduces the ash content from 5.30 wt% to 1.37 wt% by mainly removing Al and Si containing minerals. Subsequent leaching by ferric ions decreases the ash content further to 990 ppm by removing most of the pyrite and fluorides formed during the HF leaching. Calorific value of the coal shows no change following leaching, which suggests no oxidation is occurring to the coal carbonaceous matrix. The mercury and sulfur contents after the two-stage leaching sequence decrease by 40% and 26%, respectively.

08/01854 Development of fragmentation models for solid fuel combustion and gasification as subroutines for inclusion in CFD codes

Syred, N. *et al. Fuel*, 2007, 86, (14), 2221–2231.
This work arises from substantial problems found in the modelling of the gasification and combustion of solid fuel, both coal and biomass in the following different systems: coal-fired non-slagging cyclone combustors, pre-calciners on cement plant, fuel-rich inverted cyclone combustors used to simulate the time-temperature history of large utility boilers, cyclonic gasifiers for sawdust and direct firing of small gas turbines, deposition studies for slagging and fouling in large utility boilers, and prediction of final carbon in ash from pulverized coal systems. Commercial CFD codes such as Fluent are well developed and have well-proven routines for Lagrangian tracking of burning particles through complex flow fields. However what has become apparent in numerous studies is that existing models for solid fuel combustion can be adjusted to predict the initial flow field aerodynamics, sometimes the temperature, but fall down when particles have to be followed completely through a system. This is manifested with cyclone combustors and gasifiers via enhanced retention of burning particles in centrifugal force fields, which can only be resolved by changes in the particle size distribution and thus fragmentation as the particle gasify or burn. This problem also becomes apparent in studies of processes in pre-calciners and in deposition in large utility boilers and furnaces. The paper will review the literature of the fragmentation of pulverized coal

and biomass during gasification, devolatilization and combustion and relate it to observed phenomena in the type of system under consideration. The difficulties of incorporating models of fragmentation in CFD codes such as Fluent are discussed. Then the implementation of such a model in Fluent is described, together with results from a number of different systems. It is concluded that the model so implemented shows improved prediction in many difficult areas, but still needs development to better reflect actual fragmentation conditions in different experimental systems. It is concluded that the model needs to be further extended beyond the single-step fragmentation at present used, especially to include many of the fine particles known to be generated in such systems.

08/01855 Experimental study on particles mixing in an annular spouted bed

Hao, H. *et al. Energy Conversion and Management*, 2008, 49, (2), 257–266.

A novel annular spouted bed was developed and studied experimentally. The experiments were performed to examine the effects of feeding mode, air velocity and static bed height as well as particle size on particle mixing for different conditions in this device. The results show that feeding by a rotating cone greatly improves particle mixing by homogeneously projecting the particles into the annular bed. For feeding by a rotating cone, the time required to get uniform mixing laterally is shorten almost 10 times less than that for feeding at a fixed point. With increasing air velocity, the axial mixing speed increases more significantly than the lateral mixing speed. The static bed height has important effects on the uniformity of the final admixtures. With increasing static bed height, the degree of mixing of the final mixture (FDM) axially first decreases, then increases, but laterally, the FDM is monotone decreasing. The particles of small size are helpful to raise the mixing speed. In addition, the dead zone in the annular spouted bed was analysed.

08/01856 Hydrothermal upgrading of Loy Yang Brown coal – effect of upgrading conditions on the characteristics of the products

Sakaguchi, M. *et al. Fuel Processing Technology*, 2008, 89, (4), 391–396.

Hydrothermal treatment of the high-moisture containing (59%) Loy Yang brown coal was conducted in a 20 ml stainless steel autoclave at 200–350 °C for 30 and 180 min. Three treatment methods were employed: (1) conventional method (i.e. extra water was added before treatment); (2) as-received method (i.e. treatment without addition of extra water); and (3) separation method (i.e. treatment with physical separation of water and solid). Treatment using the as-received method revealed that hydrothermal conditions can be maintained in the autoclave without addition of extra water. Upgrading using the separation method yielded more effective drying especially during treatment at 350 °C, where the water content was reduced to 6%. Treatment above 250 °C led to progressive lower water content, increasing carbon and decreasing oxygen content. Calculations of the calorific values of the upgraded coals showed that hydrothermal treatment at 300 and 350 °C led to a net increase in the calorific value compared to the raw coal. Reductions in the volatile content and the changes in the physical properties of the upgraded coals significantly reduced self-ignition tendencies of the coal treated above 300 °C.

08/01857 Maceral/microlithotype partitioning with particle size of pulverized coal: examples from power plants burning Central Appalachian and Illinois basin coals

Hower, J. C. *International Journal of Coal Geology*, 2008, 73, (3–4), 213–218.

Pulverized coals from 11 power plants burning Central Appalachian coal blends and eight power plants burning Illinois Basin coal blends were studied in order to assess the petrographic nature of industrial-scale coal grinding. All coals were high volatile bituminous. Coals were wet screened at 100 (150 μ), 200 (75 μ), 325 (about 40 μ), and 500 (about 25 μ) mesh. Petrographic analysis of the whole coals and size fractions consisted of a combined maceral and microlithotype analysis. Microlithotype analysis, in particular, provides a reasonable approximation of the whole-particle composition at the scale of utility coal pulverization. In the size fractions, duroclarite, the most abundant trimaceral microlithotype, is most abundant in the coarsest fraction and least abundant in the finest fraction. Vitrite, the most abundant monomaceral microlithotype, exhibits the opposite trend. Duroclarite becomes more enriched in vitrinite towards the finer sizes. The partitioning of microlithotypes and the partitioning of macerals within the microlithotypes is indicative of the relative brittle nature of vitrite compared to the hard-to-grind trimaceral microlithotypes. Increased vitrinite in duroclarite is an indication that the microlithotype within the particular size fraction is more brittle than relatively vitrinite-depleted duroclarite in coarser fractions. The relative grindability of microlithotypes will, in turn, impact combustion efficiency.

08/01858 Stability evaluation and optimal excavated design of rock slope at Antaibao open pit coal mine, China

He, M. C. *et al. International Journal of Rock Mechanics and Mining Sciences*, 2008, 45, (3), 289–302.

Rock slope deformation stability for Antaibao open pit coal mine under mining was analysed using finite difference technique (FLAC^{3D}). Optimal excavated scheme with relatively steeper slope angle of 47° instead of 30° was successfully implemented at the west wall on the geological section 73200 of the mine area, where the three-dimensional (3D) effect of non-linear large deformation of the slope was taken into account. Physico-mechanical properties of the rock materials were obtained by laboratory tests conducted on samples cored from exploration drilling and rock blocks taken directly from the mine. A non-linear Mohr–Coulomb material model with a tension cutoff was used in all present simulations. The non-linear effect on excavated sequence was also discussed. It is demonstrated by dynamical response analysis that the action of earthquake magnitude VII (Richter) upon the relatively steeper excavated slope could not be more than that slope could bear.

08/01859 Study on the fate of As, Hg and Pb in Yima coal via sub-critical water extraction

Wang, B. *et al. Fuel*, 2007, 86, (12–13), 1822–1830.

Arsenic, lead and mercury are the major hazardous trace elements contained in coals. During coal combustion these trace elements release and emit to the atmosphere and cause harmful effects to human beings and the environment. This paper studies the fate of arsenic, lead and mercury in Chinese Yima coal by sub-critical water treatment. The experiments were performed in a semi-continuous apparatus. Demineralization, float-sink experiment and sequential chemical extraction were carried out in order to examine the transformation of occurrence mode of the three elements. The results show that with increasing temperature and residence time, the removal of As, Pb and Hg increases. At 410 °C, 15 MPa, 30 min, with water flow rate of 450 ml/h, the removal of mercury and arsenic is about 100% and 57%, respectively. It is difficult to remove lead by sub-critical water extraction. Arsenic and lead in Yima coal are associated not only with pyrite, but also with monosulfides and sulfates, other minerals including silicates, aluminum silicate, etc. and organic matter. Mercury is mainly associated with pyrite (about 75%) by adsorption, and is also associated with other minerals such as clays, silicates, aluminum silicates, etc. During sub-critical water treatment, arsenic associated with carbonates, sulfates and monosulfide, pyrite and other minerals all decrease, and that associated with organic matters increase. Only a little lead in Yima coal is removed by this process. Mercury associated with pyrite and other minerals decreases, and that associated with sulfates and monosulfides disappears after sub-critical water extraction.

08/01860 Three-dimensional time-lapse velocity tomography of an underground longwall panel

Luxbacher, K. *et al. International Journal of Rock Mechanics and Mining Sciences*, 2008, 45, (4), 478–485.

Three-dimensional velocity tomograms were generated to image the stress redistribution around an underground coal longwall panel to produce a better understanding of the mechanisms that lead to ground failure, especially rockbursts. Mining-induced microseismic events provided passive sources for the three-dimensional velocity tomography. Surface-mounted geophones monitored microseismic activity for 18 days. Eighteen tomograms were generated and high-velocity regions correlated with high abutment stresses predicted by numerical modelling. Additionally, the high-velocity regions were observed to redistribute as the longwall face retreated, indicating that velocity tomography may be an appropriate technology for monitoring stress redistribution in underground mines.

08/01861 Understanding the mechanisms behind coking pressure: relationship to pore structure

Duffy, J. J. *et al. Fuel*, 2007, 86, (14), 2167–2178.

During carbonization coal undergoes both physical and chemical changes that result in the generation of gas and tar and the formation of an intermediate plastic state. This transformation is known to generate high internal gas pressures for some coals during carbonization that translate to high pressures at the oven wall. In this study, three low volatile coals A, B and C with oven wall pressures of 100 kPa, 60 kPa and 20 kPa respectively were investigated using high-temperature rheometry, ^{1}H NMR, thermogravimetric analysis and SEM, with the primary aim to better understand the mechanisms behind the coking pressure phenomenon. Rheometer plate displacement measurements (ΔL) have shown differences in the expansion and contraction behaviour of the three coals, which seem to correlate with changes in rheological properties; while SEM images have shown that the expansion process coincides with development of pore structure. It is considered that the point of maximum plate height ($\Delta L_{\max}$) prior to contraction may be indicative of a cell opening or pore network forming process, based on analogies with other foam systems. Such a process may be considered important for coking pressure since it provides a potential mechanism for volatile escape, relieving internal gas pressure and inducing charge contraction. For coal C, which has the highest fluidity $\Delta L_{\max}$ occurs quite early in the softening process and consequently a large degree of contraction is observed; while for the lower fluidity coal B, the process is delayed since pore development and consequently wall thinning progress at a slower rate. When $\Delta L_{\max}$ is attained, a lower degree of contraction is observed because the event occurs closer to resolidification where the increasing viscosity/elasticity can stabilize the expanded pore structure. For coal A which is relatively high fluidity, but also high coking pressure, a greater degree of swelling is observed prior to cell rupture, which may be due to greater fluid elasticity during the expansion process. This excessive expansion is considered to be a potential reason for its high coking pressure.

Transport, storage

08/01862 Analysis of support by hydraulic props in a longwall working

González-Nicieza, C. *et al. International Journal of Coal Geology*, 2008, 74, (1), 67–92.

This paper presents a study of the support system in an anthracite working situated in Feixolin (northern Spain). The working is mined by the longwall method, caving being controlled by means of hydraulic props and wooden cribs. As the coal seam has an average thickness of 3.5 m and 30° slope, the workings do not meet Spanish regulations for the mining of longwall coal seams. This means that the support system must be studied and tested before it is definitively implemented in the mine. A detailed study of the materials that make up the coal seam and the surrounding rock mass was carried out, determining the geomechanical properties of these by means of both laboratory and *in situ* tests. To this end, a full scale experimental working was conditioned to carry out the tests, with special emphasis on the load plate tests and penetration load tests carried out with the actual hydraulic support props of the working. With the data thus obtained, the behaviour of the working was modelled using FLAC in order to determine the maximum pressure that the coal hanging wall and footwall is capable of supporting, as well as the density of the props and the conditions of the supports they rest on so that penetration of the props is not produced. The overall aim was to validate the intended support system for the underground mine.

Economics, business, marketing, policy

08/01863 A study of rock abrasivity and tool wear in coal measures rocks

Yarali, O. *et al. International Journal of Coal Geology*, 2008, 74, (1), 53–63.

This paper examines the relations between Cerchar abrasivity index (CAI) and petrographic properties of coal measures rocks in the Zonguldak Coal Basin, Turkey. In this study, petrographic properties and abrasivity indices of 29 sedimentary rock samples were determined and the values of CAI and petrographic analysis results were compared. A good linear relationship between CAI and average quartz grain size parameters was found. The test results also showed that abrasivity was affected by the mineralogical composition, cement type, degree of cementation, quartz content, and average quartz grain size. It was found that abrasivity of rock was decreased by the low grade of cementation between abrasive minerals. CAI values and petrographic properties were used to estimate tool consumption in underground works in the Zonguldak Coal Basin. It was observed that when CAI values increased, tool consumption increased.

08/01864 Coal and sustainable energy supply challenges and barriers

Kavouridis, K. and Koukouzas, N. *Energy Policy*, 2008, 36, (2), 693–703.

Coal is broadly recognized as secure, competitive, diversified, not vulnerable and predictable in price as an energy resource. In the power generation sector, coal is playing a dominant role in the EU-27 with 25% share of the total installed capacity and almost one-third of the power generation. The role played by the domestic resources and especially by coal is increasingly becoming the focus of the EU energy strategy. There is a strong pressure for the decarbonization of the energy mix. The emission trading scheme (ETS) can have an impact on the shift to lower carbon-intensive fuels. The impact of ETS on coal can be important, because it is very short-sighted and only defines the period up to 2008–2012. The ETS carbon dioxide (CO_2) regime must ensure that investments in coal-fired plants in the long term are supported. EU research institutes and the coal industry identified an important CO_2 reduction potential by improving the efficiency of the conversion of solid fuels into electricity. Highly efficient clean coal technologies can contribute to reasonable costs and challenge the issue of climate change. It must be pointed out that EU energy policy should now concentrate on the necessity to effectively support demonstration projects and to create the legal framework for the integrated approach of efficiency enhancement and CO_2 capture and storage (CCS). However, it is not a proper and rational approach to implement CCS before the technology is demonstrated and before it is clear that it will be commercially viable.

08/01865 Economic implications of oxyfuel application in a lignite-fired power plant

Kakaras, E. *et al. Fuel*, 2007, 86, (14), 2151–2158.

The scope of the work presented in this paper is to examine and evaluate the application of the oxyfuel combustion CO_2 capture technology in a lignite-fired power plant from an economic point of view. Results from simulations dealing with the most important features for CO_2 reduction are performed. The operational characteristics, the efficiency penalties as well as the net efficiency reduction emerging from the Greenfield application of the oxyfuel technology are presented. CO_2 capture costs and the energy requirements associated with the oxyfuel method affect significantly the cost of electricity. This paper focuses on the analysis of the techno-economic factors that result in the increase of the cost of electricity in comparison with the conventional air-fired power plant. For this reason a typical Greek lignite power plant is used as a reference case. Any technical, economic and financial assumptions applied provide a common basis for both power plants (i.e. conventional and oxyfuel) for the assessment of the change of the cost of electricity and the CO_2 capture cost. The oxyfuel simulations are performed by taking into account the adoption of measures for the exploitation of heat that would otherwise be wasted. Such measures concern both the water/steam cycle and the gas flows (e.g. the oxygen flow). Heat integration from processes – such as the air separation, the CO_2 compression and purification and the flue gas treatment – is adopted in order to lower as much as possible the efficiency penalty. The cycle calculations have been performed using the thermodynamic cycle calculation software program ENBIPRO. ENBIPRO is a powerful tool for heat and mass balance solving of complex thermodynamic circuits, calculation of efficiency, exergetic and exergoeconomic analysis of power plants. The software code models all pieces of equipment that usually appear in power plant installations and can accurately calculate all thermodynamic properties (temperature, pressure, enthalpy) at each node of the thermodynamic circuit, power consumption of each component, flue gas composition, etc. The code has proven its validity by accurately simulating a large number of power plants and through comparison of the results with other commercial software.

08/01866 Policy study on development and utilization of clean coal technology in China

Lu, X. *et al. Fuel Processing Technology*, 2008, 89, (4), 475–478.

The major obstacles to current development of clean coal technologies (CCT) are investigated, based on study of current laws, regulations and policies which have been used to accelerate CCT development in China, evaluation of implementation of these regulations, policies and economic incentives, and comparison between Chinese and foreign experiences. The evaluation of available clean coal technologies is conducted in four areas, i.e. power sector, industrial boiler, chemical production and fuel oil substitution and household use. In addition, clean coal technologies and the development plans suitable for the Chinese situation are suggested. Finally, based on technical and economic evaluation, policy and countermeasure recommendations on development of Chinese clean coal technology are made.

08/01867 Possible optimal configurations for the ZECOMIX high efficiency zero emission hydrogen and power plant

Calabrò, A. *et al. Energy*, 2008, 33, (6), 952–962.

Coal use for electricity generation will continue growing in importance. In the present work the optimization of a high efficiency and zero emissions coal-fired plant, which produces both hydrogen and electricity, has been developed. The majority of this paper concerns an integration of gasification unit, which is characterized by coal hydrogasification and carbon dioxide (CO_2) separation, with a power island, where a high-hydrogen content syngas is burnt with pure oxygen stream. Another issue is the high temperature CO_2 desorption. Because of the elevated temperature heat supply, the regeneration process affects the overall performance of ZECOMIX plant. An advanced steam cycle characterized by a medium pressure steam compressor and expander has been considered for power generation. A preliminary study of different components leads to analyse possible routes for optimization of the whole plant. The plant equipped with a CO_2 capture unit could reach efficiency close to 50%. The simulations of a thermodynamic model were carried out using the software ChemCAD. This study is a part of a larger research project, named ZECOMIX, led by ENEA (Italian Research Agency for New technologies, Energy and Environment), other partners being ANSALDO and different Italian Universities. It is aimed at analysing an integrated hydrogen and power production plant.

08/01868 Renewable energy and coal use in Turkey

Yilmaz, A. O. *et al. Renewable Energy*, 2008, 33, (5), 950–959.

Turkey becomes more dependent on foreign countries for fulfilling its energy needs day by day. While 77% of the overall primary energy consumption in 1970 was met by the domestic energy sources, this percentage decreased to 28% in 2003. As for the electricity production, while 89% of the produced electricity was produced by using the domestic sources, this percentage decreased to 68% in 1970 and 44% in 2003. The percentage of dependence on foreign countries increased year by year and reached 56% in 2003. The energy sources of Turkey are renewable energy sources and coal. If both of these energy sources are used effectively, Turkey will have a capacity to produce its overall electricity production using its own sources. The incorrect policies applied in Turkey introduced oil as a primary energy source for electricity production in 1970s and Turkey defrayed the cost of this wrong application severely by oil crisis. After 2000, natural gas, which was completely imported, was introduced as an energy source and its share in electricity production reached 45%. It is vital for Turkey to question this situation in order to ensure a sustainable development using reliable energy sources.

08/01869 Sustainable clean coal power generation within a European context – the view in 2006

Minchener, A. J. and McMullan, J. T. *Fuel*, 2007, 86, (14), 2124–2133.

The future use of coal will require strict environmental compliance with an increasing need to minimize emissions of CO_2, particularly from power plants. A pan-European approach is being established to ensure that EU industry can have available, by 2020, fossil fuel power plants that are either capable of capturing almost all their CO_2 emissions in an economically viable manner, or are designed to include CO_2 capture systems ('capture-ready'). The overall aim is to provide a significant impetus to research, development, demonstration and deployment activities such that coal and other fossil fuels can be used in a sustainable manner.

Derived solid fuels

08/01870 A possibility of the production of carbon nanotubes from heavy hydrocarbons

Kidena, K. *et al. Fuel Processing Technology*, 2008, 89, (4), 449–454.

A possibility of the production of carbon nanotubes from heavy hydrocarbon resources derived from natural asphalt was examined. Before the use of heavy hydrocarbons, pure compound, toluene was used as the pure substrate to establish the reaction system for the production of carbon nanotubes. Carbon nanotubes were found in the carbonaceous product deposited on inner wall of a quartz tube and at the exit of the tube. The carbonaceous product was observed by scanning electron microscopy and analysed by temperature-programmed oxidation experiments to identify the presence of carbon nanotubes. Based on the reaction system and reaction conditions with toluene, the production of nanotubes was examined by using heavy hydrocarbons such as asphaltene and maltene fractions from a natural asphalt. Under selected reaction conditions including the reaction temperature and the amount of the catalyst, carbon nanotubes with a diameter of 30–60 nm were found.

08/01871 Behaviour of the elements introduced with the fuels in their distribution and immobilization between the coal–petroleum coke IGCC solid products

Alvarez-Rodríguez, R. *et al. Fuel*, 2007, 86, (14), 2081–2089.

In this research on the solid products of the Elcogas IGCC plant (Puertollano, Spain) the influence of the two fuels, coal and pet coke, on the composition of the fly ashes and slag is demonstrated and how the majority of the elements are provided by the coal and only some as V, Ni and Mo are provided by the pet coke. The different nature of slag and fly ashes is highlighted and how the different elements are distributed between them that in general follow the indications of the mathematical models. The passage of the elements into gaseous phase is calculated. The fly ashes are some products of very fine granulometry that present problems of solubilization of a series of elements and therefore of deposition. Their inertization has been investigated by calcination at 1000 °C and with additives. Some good results have been obtained.

08/01872 Impact of low-cost filler material on coke quality

Barranco, R. *et al. Fuel*, 2007, 86, (14), 2179–2185.

An investigation was made to study the influence of low-cost filler material such as non-coking coals and refuse-derived fuel (RDF) on coke quality. Interfaces between textural components within the cokes were successfully characterized and the derived interface quality index showed some cokes contained more 'good' quality interfaces than others. The addition of filler coals and RDF to the coking coal increased the proportion of 'poor' interfaces'. A good correlation between coke strength, derived from a small drum test, and interface quality index was observed. During heat treatment of cokes at 1600 °C both metallic and non-metallic micro-constituents were found to undergo some transformation as revealed by the SEM surface morphology examination. Although heat treatment caused some fractures to enlarge and others to emerge, its effect on the quality of the coke was not significant. Based on the results from the samples studied, there were some indications of the potential use of RDF material in the production of coke as there were minimal adverse effects on the quality of coke produced.

08/01873 Modeling of catalytic coke formation in thermal cracking reactors

Mohamadalizadeh, A. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 134–139.

At the start-up period, the most important mechanism in the coke production with a clean reactor surface is the catalytic mechanism. The study of this mechanism can be very useful for the better comprehension of the coke production process. In this paper, a model was designed for such a production through the utilization of a catalytic mechanism and a kinetic model, capable of interpreting the catalytic coke production on the reactor surface. For the determination of the model reliability, the experimental data related to the naphtha feed, existing in literature, were used. In addition, the constant parameters of the model, the velocity and the activation energy constants, associated to the kinetic model, were calculated. The results of the developed model were in satisfactory agreement with the experimental data. Eventually, the catalytic coke amount in comparison with the total coke production on the reactor surface and its significance were under investigation.

08/01874 Pelletised fuel production from coal tailings and spent mushroom compost – Part I. Identification of pelletisation parameters

Ryu, C. *et al. Fuel Processing Technology*, 2008, 78, (3), 269–275.

This study investigates the technology of manufacturing pellet blends for energy production from two discarded materials in industry. Coal tailings material is the fine discard produced as a result of coal cleaning. Although it still has a significantly high calorific value, over a million tonnes of coal tailings are deposited in lagoons every year in the UK alone. Spent mushroom compost (SMC) consists of fibrous compost substrate and a wet casing layer used during mushroom production. In the form of pellets, these materials become more homogeneous, easily stored and transported, and suitable for use in power plants or gasifiers. The characterization of the fuel properties shows that the two materials have a complimentary status for pelletization and energy production in terms of particle types, carbon source, calorific value and volatile matter content. Pelletization tests were carried out using a small compression rig for various pressures, moisture contents and mixture compositions. The quality of the pellets was assessed using density, swelling, tensile strength and durability. It was necessary to keep the moisture contents for coal tailings at about 10% and for SMC at 20% before pelletization in order to maximize the bonding strength of the originally wet materials. Pressures above 6000 psi did not produce noticeably denser or stronger pellets. The pellets from coal tailings and SMC blends had a tensile strength proportional to the SMC fraction. The SMC pellets were more durable than the coal tailing pellets due to the intertwined compost fibres. It was also noted that the SMC addition to the coal tailings did not increase the durability of the pellets due to the limited binding effect between the two materials.

08/01875 Pelletised fuel production from coal tailings and spent mushroom compost – Part II. Economic feasibility based on cost analysis

Ryu, C. *et al. Fuel Processing Technology*, 2008, 78, (3), 276–283.

Due to the growing market for sustainable energy, in order to increase the quality of the fuels, pellets are being produced from various materials such as wood and other biomass energy crops, and municipal waste. This paper presents the results from an economic feasibility study for pellet production using blends of two residue materials: coal tailings from coal cleaning and spent mushroom compost (SMC) from mushroom production. Key variables such as the mixture composition, raw material haulage and plant scale were considered and the production costs were compared to coal and biomass energy prices. For both wet materials, the moisture content was the critical parameter that influenced the fuel energy costs. The haulage distance of the raw materials was another factor that can pose a high risk. The results showed that the pellet production from the above two materials can be viable when a less energy-intensive drying process is utilized. Potential market outlets and ways to lower the costs are also discussed in this paper.

08/01876 Preparation and characterization of activated carbon from date stones by physical activation with steam

Bouchelta, C. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 70–77.

Activated carbons are produced from wastes of Algerian date stones by pyrolysis and physical activation in the presence of water vapour into a heated fixed-bed reactor. The effect of pyrolysis temperature and activation hold time on textural and chemical surface properties of raw date stones and carbon materials produced are studied. As expected, the percentage yield decreases with increase of activation temperature and hold time. The characterization of carbon materials is performed by scanning electron microscopy. X-ray diffraction, Fourier transform infrared spectroscopy and nitrogen adsorption. Results show the presence of cellulose and hemicellulose in the raw material, and the predominance of carbon and graphite after pyrolysis. Different oxygen-containing functional groups are found in the raw material while aromatic structures are developed after pyrolysis and activation. The best specific surface area ($635\,m^2\,g^{-1}$) and microporous volume ($0.716\,cm^3\,g^{-1}$) are obtained when the date stones are grinded, pyrolysed at 700 °C under a $100\,cm^3\,min^{-1}$ nitrogen flow and then activated under water vapour at 700 °C for 6 h.

08/01877 The use of petroleum coke as fuel in chemical-looping combustion

Leion, H. *et al. Fuel*, 2007, 86, (12–13), 1947–1958.

Chemical-looping combustion is a novel technique used for CO_2 separation that previously has been demonstrated for gaseous fuel. This work demonstrates the feasibility of using solid fuel (petroleum coke) in chemical-looping combustion (CLC). Here, the reaction between the oxygen carrier and solid fuel occurs via the gasification intermediates, primarily CO and H_2. A laboratory fluidized-bed reactor system for solid fuel, simulating a CLC-system by exposing oxygen-carrying particles to alternating reducing and oxidizing conditions, has been developed. In each reducing period, 0.2 g of petroleum coke was added to 20 g of oxygen carrier composed of 60% active material of Fe_2O_3 and 40% inert $MgAl_2O_4$. The effect of steam and SO_2 concentration in the fluidizing gas was investigated as well as effect of temperature. The rate of reaction was found to be highly dependent on the steam and SO_2 concentration as well as the temperature. Also shown was that the presence of a metal oxide enhances the gasification of petroleum coke. A preliminary estimation of the oxygen carrier inventory needed in a real CLC system showed that it would be below $2000\,kg/MW_{th}$.

02 LIQUID FUELS

Sources, properties, recovery

08/01878 A new experimental setup for the liquid–solid phase transition determination in crude oils under high pressure conditions

Rizzo, A. *et al. Fuel*, 2007, 86, (12–13), 1758–1764.

A high pressure apparatus based on two sapphire windows high pressure cell coupled with a detection system of the reflected and refracted light intensities coming from a laser beam was designed to determine the phase transitions by the measurement of the light intensity change. The setup was used to measure the wax disappearance temperature under pressure up to 100 MPa in pure component, synthetic complex mixtures made up of distributions of n-paraffins ranging from n-C_{20} to n-C_{42}. Finally a real stabilized condensate was successfully investigated and the sensitivity of the detection system was demonstrated on a dark crude oil.

08/01879 Characterisation of heavy petroleum fractions using modified molecular-type homologous series (MTHS) representation

Gomez-Prado, J. *et al. Energy*, 2008, 33, (6), 974–987.

The molecular characterization of refinery feedstocks is a challenging task since, typically, a vast number of components are present in the mixture. Non-experimental approaches for characterization of hydrocarbon streams fall into three categories: pseudo-component, compound class and average structural parameter methods. In this work, a new compound class approach is used to represent any hydrocarbon stream (with boiling range up 700 °C) via a modified molecular-type homologous series matrix. The fraction of each component/cut in the feedstock stream is estimated by minimizing the discrepancies between the bulk physical properties and the ones reconstructed through the characterization method. Mixture properties are calculated by applying Kay's mixing rule, for each cut. The paraffinic, naphthenic and aromatic content of each cut of the analysed mixture can then be determined. To test the method, 15 olefin-free petroleum samples, from refineries all over the world, covering boiling ranges from 120 to 615 °C were characterized. The results show good agreement with the experimental data. A technique for integrating the characterization approach with refinery lumped kinetic models is also presented. It is based on the pivot method appropriately modified to use the information provided by the characterization procedure in order to obtain the necessary input for kinetic/reaction models, ensuring species mass conservation.

08/01880 Characterization of Algerian Hassi-Messaoud asphaltene structure using Raman spectrometry and X-ray diffraction

Bouhadda, Y. *et al. Fuel*, 2007, 86, (12–13), 1855–1864.

Asphaltenes derived from Algerian oil wells were characterized by Raman spectrometry to investigate their molecular structures in solid-state. The aromatic sheet diameter (L_a) was estimated using the integrated intensities of the G and the D1 mode, along with the Tuinstra equation. The values obtained for three Algerian Hassi-Messaoud asphaltene samples are on the same order as the literature values and also consistent with the X-ray diffraction results. The Raman spectra corresponding to the G and the D bands can be fitted with Gaussian, Lorentzian, and Gaussian/Lorentzian hybrid functions in a self-consistent manner. A three peak fitting procedure found that the Gaussian/Lorentzian hybrid function with G being Gaussian and D Lorentzian is the best combination. Incorporation of the X-ray data on the height of the crystallite, L_c, gives rise to an estimate of eight asphaltene molecules in each asphaltene aggregate.

08/01881 Coking behavior and catalyst deactivation for catalytic pyrolysis of heavy oil

Meng, X. *et al. Fuel*, 2007, 86, (12–13), 1720–1726.

For the catalytic pyrolysis of heavy oil on catalyst CEP-1, coking behaviour was investigated in a confined fluidized bed reactor. Coke content on the spent catalyst decreases with the increase of H/C mol ratio of feeds and catalyst-to-oil weight ratio, while it increases with the enhancement of reaction temperature. An empirical model is proposed to predict the coke content based on feed properties and operating conditions. The predicted coke content is close to the experimental data. The relationship between micro-activity index of catalysts and coke content is studied. A coking deactivation model for pyrolysing catalysts is established, and then model parameters are determined by the least square regression analysis. According to the deactivation model, the variations of relative activity of catalysts with both residence time of catalysts and catalyst-to-oil weight ratio are predicted.

08/01882 Detailed chemical kinetic models for the low-temperature combustion of hydrocarbons with application to gasoline and diesel fuel surrogates

Battin-Leclerc, F. *et al. Progress in Energy and Combustion Science*, 2008, 34, (4), 440–498.

This paper presents a review of gas-phase detailed kinetic models developed to simulate the low-temperature oxidation and autoignition of gasoline and diesel fuel components (alkanes, ethers, esters, alkenes, cycloalkanes, aromatics, including from four atoms of carbon) and of mixtures of several of them, which have been proposed as surrogates. The recently proposed models are summarized, as well as the experimental results available for their validation. A comparison between the major models in terms of considered elementary steps and associated rate constants is also proposed.

08/01883 Kerogen chemistry 5. Anhydride formation in, solvent swelling of, and loss of organics on demineralization of Kimmeridge shales

Larsen, J. W. and Flores, C. I. *Fuel Processing Technology*, 2008, 89, (4), 314–321.

The results of three short and related, but experimentally independent, studies of four Kimmeridge shales and their kerogens are reported. Differential scanning calorimeter studies of the kerogens reveal that three of the four show evidence of anhydride formation when heated at 20 °C/min between 50 °C and 180 °C. There is no regular rank dependence of anhydride formation. After solvent swelling in tetrahydrofuran (THF), extracted organics were isolated from the THF and the recovered kerogens were swollen a second time in fresh THF. The second solvent swelling ratios were slightly larger than the first because the presence of the extracts in the original THF lowers solvent activity thus reducing swelling. The shales were demineralized in the usual way except that methylene chloride was added to dissolve any organics that were liberated from the rock as a consequence of mineral dissolution. Small amounts of organics were found in the methylene chloride supporting Price and Clayton's conclusion that organics are expelled from the kerogen and are present in lacunae in the minerals.

08/01884 Macroscopic diesel fuel spray shadowgraphy using high speed digital imaging in a high pressure cell

Klein-Douwel, R. J. H. *et al. Fuel*, 2007, 86, (12–13), 1994–2007.

Spray formation from diesel fuel injection through a realistic heavy-duty multi-hole common rail injector is studied in a newly developed high pressure, high temperature cell, using digital high speed shadowgraphy at 4500 frames per second. Care is taken to establish accurate synchronization between camera and injection system and because of the relatively large exposure time, an effective camera image time is calculated for every frame. Further emphasis is given to determining the actual start of fuel mass injection by comparing (for each injection) a predetermined, rail pressure dependent needle relaxation distance to the actual needle lift signal. The spatiotemporal evolution of the spray is found to reproduce well in general, but often sprays suffer from short-lived, small, laterally moving anomalies, which influence axial motion and the spray cone angle. High speed shadowgraphy allows this to be observed and taken into account. After an overview of methods found in the literature, an algorithm for geometrical analysis is presented, which is based on an extension of a combination of those methods. In this algorithm, a local spray angle $\theta i(x)$ is determined from lateral cross-sections at 80% of the shadow level in order to encompass most of the spray without being too sensitive to background noise. The macroscopic cone angle θ_{cone} is derived from the approximate constancy of $\theta i(x)$ over a relatively long axial distance. Spray penetration is obtained by lateral integration of the spray shadow. A procedure for accurate correlation of spray growth with time shows that the growth is proportional to tb with $b = 0.57 \pm 0.02$ for a common rail pressure of 150 MPa and a gas density 33 kg/m^3 (N_2 at room temperature). The exact value of b is very sensitive to uncertainties in synchronization and the start of injection determination. The spray cone angle θ_{cone} is not constant, but varies with time during an injection, mainly as a result of spray shape changes.

08/01885 Plastic and damage behaviour of a high strength X100 pipeline steel: experiments and modelling

Tanguy, B. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (5), 322–335.

The purpose of this work is to develop a constitutive model integrating anisotropic behaviour and ductile damage for a X100 pipeline steel. The model is based on a set of experiments on various smooth, notched and cracked specimens and on a careful fractographic examination of the damage mechanisms. The model is based on an extension of the Gurson–Tvergaard–Needleman model which includes plastic anisotropy. Provided brittle delamination is not triggered, the developed model can accurately describe the plastic and damage behaviour of the material. The model is then used as a numerical tool to investigate the effect of plastic anisotropy and delamination on ductile crack extension. It is shown in particular that it is not possible to obtain a unified description of rupture properties for notched and cracked specimens tested along different directions without accounting for plastic anisotropy.

08/01886 Psychrometric charts for water vapour in natural gas

Shallcross, D. C. *Journal of Petroleum Science and Engineering*, 2008, 61, (1), 1–8.

Psychrometric charts present in a graphical form physical property data for gas systems involving one or more non-condensing gas components and a single condensing vapour component. Originally limited to studying the humid air system of water vapour in dry air, the theory behind preparing psychrometric charts for water vapour in natural gas is presented. To illustrate the technique two charts are prepared for a system in which the natural gas is 80.0 mol% methane, 15.0 mol% ethane and 5.0 mol% propane. One chart is prepared for the temperature range of 0 to 60 °C at a system pressure of 101.3 kPa and the other chart for the range of 40 to 110 °C at a system pressure of 400.0 kPa. The charts are based upon semi-theoretical equations and make use of published physical property data and correlations. The behaviour of the gas mixture is characterized by the virial equation of state truncated at the third term. The charts are constructed with the dry bulb temperature and absolute humidity scales as the orthogonal axes. Curves of constant adiabatic saturation temperature, constant relative humidity, constant gas specific volume and constant enthalpy deviation are plotted on the charts. Using the theory presented psychrometric charts for any temperature range, system pressure and natural gas composition may be prepared.

08/01887 Thermal conductivity and latent heat thermal energy storage characteristics of paraffin/expanded graphite composite as phase change material

Sari, A. and Karaipekli, Y. *Applied Thermal Engineering*, 2007, 27, (8–9), 1271–1277.

This study aimed determination of proper amount of paraffin (*n*-docosane) absorbed into expanded graphite (EG) to obtain form-stable composite as phase change material (PCM), examination of the influence of EG addition on the thermal conductivity using transient hot-wire method and investigation of latent heat thermal energy storage (LHTES) characteristics of paraffin such as melting time, melting temperature and latent heat capacity using differential scanning calorimetry (DSC) technique. The paraffin/EG composites with the mass fraction of 2%, 4%, 7%, and 10% EG were prepared by absorbing liquid paraffin into the EG. The composite PCM with mass fraction of 10% EG was considered as form-stable allowing no leakage of melted paraffin during the solid–liquid phase change due to capillary and surface tension forces of EG. Thermal conductivity of the pure paraffin and the composite PCMs including 2, 4, 7 and 10 wt% EG were measured as 0.22, 0.40, 0.52, 0.68 and 0.82 W/m K, respectively. Melting time test showed that the increasing thermal conductivity of paraffin noticeably decreased its melting time. Furthermore, DSC analysis indicated that changes in the melting temperatures of the composite PCMs were not considerable, and their latent heat capacities were approximately equivalent to the values calculated based on the mass ratios of the paraffin in the composites. It was concluded that the composite PCM with the mass fraction of 10% EG was the most promising one for LHTES applications due to its form-stable property, direct usability without a need of extra storage container, high thermal conductivity, good melting temperature and satisfying latent heat storage capacity.

08/01888 V/Ni ratio as a parameter in palaeoenvironmental characterisation of nonmature medium-crude oils from several Latin American basins

Galarraga, F. *et al. Journal of Petroleum Science and Engineering*, 2008, 61, (1), 9–14.

Statistical descriptive analyses were performed taking into account sulfur, vanadium and nickel concentrations in several non-mature crude oil samples collected in the last few years from various Venezuelan and Spanish basins. Techniques used included flame atomic absorption spectrometry and energy-dispersive X-ray fluorescence spectroscopy. The results allow us to obtain a generic diagram in which four zones are well defined by their limit V/Ni ratios or Ni contents. Although previous works established intervals with reference to V/Ni ratios, this is nonetheless one of the first times that data are statistically considered with the aim of obtaining and evaluating the validity of a diagram plot to make it possible to determine the type of environment in which organic matter was deposited prior to any crude oil. Such a diagram is useful in establishing the palaeoenvironmental redox conditions that prevailed in the corresponding source rocks during their deposition. It is important to emphasize that this diagram can be applied as a geochemical exploration tool in medium-crude oils from other petroliferous basins in order to significantly reduce the costs and time of oil prospecting.

Transport, refining, quality, storage

08/01889 An algorithm for predicting the hydrodynamic and mass transfer parameters in bubble column and slurry bubble column reactors

Lemoine, R. *et al. Fuel Processing Technology*, 2008, 89, (4), 322–343.

A large number of experimental data points obtained in the laboratory as well as from the literature, covering wide ranges of reactor geometry (column diameter, gas distributor type/open area), physicochemical properties (liquid and gas densities and molecular weights, liquid viscosity and surface tension, gas diffusivity, solid particles size/density), and operating variables (superficial gas velocity, temperature and pressure, solid loading, impurities concentration, mixtures) were used to develop empirical as well as Back-Propagation Neural Network (BPNN) correlations in order to predict the hydrodynamic and mass transfer parameters in bubble column reactors (BCRs) and slurry bubble column reactors (SBCRs). The empirical and BPNN correlations developed were incorporated in an algorithm for predicting gas holdups (ε_G, $\varepsilon_{\text{G-Small}}$, $\varepsilon_{\text{G-Large}}$); volumetric liquid-side mass transfer coefficients (k_La, k_La_{Small}, $k_La_{\text{-}Large}$); Sauter mean bubble diameters (d_S, $d_{S\text{-}Small}$, $d_{S\text{-}Large}$); gas–liquid interfacial areas (a, a_{Small}, a_{Large}); and liquid-side mass transfer coefficients (k_L, $k_{L\text{-}Large}$, $k_{L\text{-}Small}$) for total, small and large gas bubbles in BCRs and SBCRs. The developed algorithm was used to predict the effects of reactor diameter and solid (alumina) loading on the hydrodynamic and mass transfer parameters in the Fisher–Tropsch (F–T) synthesis for the hydrogenation of carbon monoxide in a SBCR, and to predict the effects of presence of organic impurities (which decrease the liquid surface tension) and air superficial mass velocity in the Loprox process for the wet air oxidation of organic pollutants in a BCR. In the F–T process, the predictions showed that increasing the reactor diameter from 0.1 to 7.0 m and/or increasing the alumina loading from 25 to 50 wt.% significantly decreased ε_G, k_La_{H2} and k_La_{CO} and increased d_S. The decrease of the total gas holdup was found to be controlled by the holdup of small gas bubbles. The increase of the Sauter mean bubble diameter increased both k_{LH2} and k_{LCO}, however, the decrease of the total gas holdup coupled with the increase of d_S resulted in a dramatic decrease of the gas–liquid interfacial area, a, and subsequently k_La_{H2} and k_La_{CO}. Thus, in the churn-turbulent flow regime, the hydrodynamic and mass transfer behaviours of the F–T SBCR were controlled by the holdup and the gas–liquid interfacial area of small bubbles. In the Loprox process, the predictions showed that increasing the liquid surface tension (removal of organic impurities from water) significantly increased d_S and decreased both ε_G and k_La_{O2}. The decrease of the total gas holdup with increasing liquid-phase surface tension was due mainly to the decrease of the liquid-phase foamability which led to the decrease of the holdup of small gas bubbles. The increase of the Sauter mean bubble diameter and the decrease of the total gas holdup resulted in a strong decrease of the gas–liquid interfacial area, and subsequently k_La_{O2}. Increasing the air superficial mass velocity increased ε_G, d_S, a, $k_{L\text{-}O2}$ and k_La_{O2}. Within the conditions used in the Loprox BCR, the hydrodynamics and mass transfer parameter behaviours of the process appeared also to be controlled by the gas holdup of small gas bubbles; and the gas–liquid interfacial area.

08/01890 Measurement of biodiesel concentration in a diesel oil mixture

Aliske, M. A. *et al. Fuel*, 2007, 86, (10–11), 1461–1464.

After the development and consolidation of automotive ethanol technology in the last 30 years, Brazil is starting the development of biodiesel technology pushed by the coming oil crisis. Since, the Brazilian biodiesel law sets the percentiles of biodiesel mixed in diesel oil 2% after 2008, and to 5% after 2013, the development of a method to measure such mixture percentiles becomes necessary. A method of measurement is presented that covers the full range of mixtures (0–100%) of biodiesel in diesel oil using mid infrared spectroscopy. It is shown that the carbonyl (C=O) absorption peak, which is present only in biodiesel, presents power law proportionality with mixture percentile of 0.889 for peak area and 0.841 for peak height, respectively. Therefore it becomes possible to measure mixture percentiles of biodiesel in diesel oil, even at very low concentrations, allowing quality control and law enforcement.

08/01891 Thermal impact of the products pipeline on the crude oil pipeline laid in one ditch – the effect of pipeline interval

Yu, B. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 597–609.

Numerical simulations are carried out to study the thermal impact of the cold products pipeline on the hot crude oil pipeline of the steady state. The pipelines studied are those used in the West pipelines in China. The physical properties of North Xinjiang crude oil and those of 90# gasoline were used in this study. The effect of pipeline interval on the thermal impact is studied in details at various conditions.

08/01892 Transient pressure behavior of Bingham non-Newtonian fluids for horizontal wells

Owayed, J. F. and Tiab, A. B. *Journal of Petroleum Science and Engineering*, 2008, 61, (1), 21–32.

Heavy oil production in horizontal wells has gained a lot of attention in Kuwait. A field example of heavy oil and water flow was presented in a horizontal well. The field example is from Kuwait in Burgan Formation which is in Managish Field. They utilized advance production logging tool with distributed velocity and hold up distribution using tracer conveyance in sand screen completion. Unfortunately in Kuwait, interpretation of heavy oil horizontal well test data is still not well-understood compared with those for vertical well. Pressure transient modelling and analysis effort in the petroleum industry in Kuwait and elsewhere has mainly concentrated on the behaviour of Newtonian fluids in homogeneous and heterogeneous reservoirs. Very little information is presently available on modelling of transient flow behaviour of non-Newtonian fluids in reservoirs. This work presents new procedures, similarly to the *TDS* technique, for analysing transient pressure tests of Bingham non-Newtonian fluids for horizontal wells. The flow of a slightly compressible Bingham fluid is discussed, and new analytical equations based on pressure and pressure derivative behaviour of horizontal wells are developed. A simple log–log plot of pressure and pressure derivative with time provides accurate results of reservoir parameters so that both type-curve matching and multiple specialized plots are avoided. A step-by-step procedure for calculating reservoir and well parameters without type curve matching or regression analysis for six different cases is included in this work.

08/01893 Viscosity measurements on saturated gas-expanded liquid systems – ethanol and carbon dioxide

Sih, R. *et al. The Journal of Supercritical Fluids*, 2008, 43, (3), 460–468.

A recently developed method of falling-weight viscometry was employed to determine the experimental viscosities of the gas-expanded liquid system of ethanol and carbon dioxide at saturation. By adding carbon dioxide into an isochoric system containing metered amounts of ethanol, carbon dioxide concentrations within the gas-expanded liquid system were systematically varied between 0.15 and 0.80 mole fraction in 0.05 increments at constant system temperatures of 25, 30, 35 and 40 °C. Similar to the gas-expanded liquid system of methanol and carbon dioxide, an increase in carbon dioxide concentration in the liquid phase, liquid volume expansion, liquid density and system pressure resulted in a decrease in liquid phase viscosity. The significance of system temperature however, is more apparent with the gas-expanded liquid system of ethanol and carbon dioxide when compared to the gas-expanded liquid system of methanol and carbon dioxide. At equal compositions but varying system temperatures, not only is the viscosity of the ethanol and carbon dioxide system affected to a greater extent, the point at which viscosity reduction is insignificant with an increase in carbon dioxide composition occurs earlier with increasing system temperatures. The estimation of liquid phase viscosities of gas-expanded liquid systems is therefore difficult without experimental data.

Economics, business, marketing, policy

08/01894 A new approach for crude oil price analysis based on empirical mode decomposition

Zhang, X. *et al. Energy Economics*, 2008, 30, (3), 905–918.

The importance of understanding the underlying characteristics of international crude oil price movements attracts much attention from academic researchers and business practitioners. Due to the intrinsic complexity of the oil market, however, most of them fail to produce consistently good results. Empirical mode decomposition (EMD), recently proposed by Huang et al., appears to be a novel data analysis method for non-linear and non-stationary time series. By decomposing a time series into a small number of independent and concretely implicational intrinsic modes based on scale separation, EMD explains the generation of time series data from a novel perspective. Ensemble EMD (EEMD) is a substantial improvement of EMD which can better separate the scales naturally by adding white noise series to the original time series and then treating the ensemble averages as the true intrinsic modes. In this paper, the authors extend EEMD to crude oil price analysis. First, three crude oil price series with different time ranges and frequencies are decomposed into several independent intrinsic modes, from high to low frequency. Second, the intrinsic modes are composed into a fluctuating process, a slowly varying part and a trend based on fine-to-coarse reconstruction. The economic meanings of the three components are identified as short term fluctuations caused by normal supply-demand disequilibrium or some other market activities, the effect of a shock of a significant event, and a long term trend. Finally, the EEMD is shown to be a vital technique for crude oil price analysis.

08/01895 An ‘oil’igopoly theory of exploration

Boyce, J. R. and Vojtassak, L. *Resource and Energy Economics*, 2008, 30, (3), 428–454.

This paper develops a theory of ‘oil’igopoly exploration of an exhaustible resource. Strategic exploration and production are jointly derived in a three period subgame perfect equilibrium. While the ‘oil’igopoly theory of exploration shares many features with non-strategic models of exploration and production, there is one important difference. The ‘oil’igopoly theory of exploration predicts that firms who exhaust their proved reserves before they can convert their unproved reserves into proved reserves have an incentive to over-explore, relative to the Nash equilibrium level of exploration. A simple empirical prediction is that firms holding smaller proved reserves should be observed doing more exploration. This prediction is consistent with country-level production and reserve data in the post-World War II era.

08/01896 Development of an advanced, thermally stable, coal-based jet fuel

Balster, L. M. *et al. Fuel Processing Technology*, 2008, 89, (4), 364–378.

A candidate coal-based jet fuel that would serve the dual purpose of providing propulsion energy and excellent heat-sink capabilities was produced at pilot-plant scale by hydrotreating a 1:1 mixture of coal-derived refined chemical oil and petroleum-derived light cycle oil. The fuel was characterized using current specification methods for JP-8 fuel. Oxidative and pyrolytic thermal stability tests were conducted. Combustion tests were performed in a model high-pressure gas turbine combustor and in a T-63 turboshaft engine. Low-temperature viscosity properties and O-ring swelling were also evaluated. The candidate coal-based fuel meets most JP-8 specifications, although a few results were outside the current specification limits. The major hydrocarbon class in the coal-based fuel is cycloalkanes (e.g. decalin and its derivatives), which accounts for this fuel being significantly more dense than JP-8. The higher density could be of importance for volume-limited applications in aircraft and missiles. The candidate coal-based fuel showed excellent thermal stability, better than a JP-8 containing the currently qualified JP-8+100 additive package. In the model combustor, soot formation characteristics were essentially identical to JP-8; in the T-63 engine, the overall emissions produced were only slightly greater than from a typical JP-8. The candidate coal-based fuel appears to remain a single-phase liquid down to $-70\,^{\circ}\mathrm{C}$, desirable behaviour for long-duration, high-altitude flights. The coal-based fuel has the same swelling characteristics for nitrile O-rings as does JP-8.

08/01897 Market structure and price adjustment in the U.S. wholesale gasoline markets

Oladunjoye, O. *Energy Economics*, 2008, 30, (3), 937–961.

The issue of sticky prices in US wholesale gasoline market is re-examined allowing for the effect of market structure due to increased market concentration caused by mergers, acquisitions and joint ventures which started in the late 1990s in the US oil industry. The effects of market structure on the pattern of price adjustment were investigated based on the notion that increased market concentration leads to downward price stickiness and asymmetric short-run price adjustment in the transmission of crude price changes to wholesale gasoline price. It is found that market concentration has an insignificant asymmetric effect on the speed of price adjustment but a significant asymmetric effect on short-run price adjustments in the response of wholesale gasoline prices to crude price shocks in three US wholesale markets. Furthermore, the signs on the coefficients of market concentration effects on price dynamics in the models support the assertion that increased market concentration leads to downward price stickiness in only one of the three markets examined. Overall, the results indicate that market structure does not have a strong effect on the dynamics of price adjustment.

08/01898 Mitigation of maximum world oil production: shortage scenarios

Hirsch, R. L. *Energy Policy*, 2008, 36, (2), 881–889.

A framework is developed for planning the mitigation of the oil shortages that will be caused by world oil production reaching a maximum and going into decline. To estimate potential economic impacts, a reasonable relationship between percentage decline in world oil supply and percentage decline in world GDP was determined to be roughly 1:1. As a limiting case for decline rates, giant fields were examined. Actual oil production from Europe and North America indicated significant periods of relatively flat oil production (plateaus). However, before entering its plateau period, North American oil production went through a sharp peak and steep decline. Examination of a number of future world oil production forecasts showed multi-year rollover/roll-down periods, which represent pseudoplateaus. Consideration of resource nationalism posits an oil exporter withholding scenario, which could potentially overwhelm all other considerations. Three scenarios for mitigation planning resulted from this analysis: (1) a best case, where maximum world oil production is followed by a multi-year plateau before the onset of a monatomic decline rate of 2–5% per year; (2) a middling case, where world oil production reaches a maximum, after which it drops into a long-term, 2–5% monotonic annual decline; and finally (3) a worst case, where the sharp peak of the middling case is degraded by oil exporter withholding, leading to world oil shortages growing potentially more rapidly than 2–5% per year, creating the most dire world economic impacts.

08/01899 Oil vulnerability index of oil-importing countries

Gupta, E. *Energy Policy*, 2008, 36, (3), 1195–1211.

This paper assesses the relative oil vulnerability of 26 net oil-importing countries for the year 2004 on the basis of various indicators – the ratio of value of oil imports to gross domestic product (GDP), oil consumption per unit of GDP, GDP per capita and oil share in total energy supply, ratio of domestic reserves to oil consumption, exposure to geopolitical oil market concentration risks as measured by net oil import dependence, diversification of supply sources, political risk in oil-supplying countries, and market liquidity. The approach using the principal component technique has been adopted to combine these individual indicators into a composite index of oil vulnerability. Such an index captures the relative sensitivity of various economies towards developments of the international oil market, with a higher index indicating higher vulnerability. The results show that there are considerable differences in the values of individual indicators of oil vulnerability and overall oil vulnerability index among the countries (both inter-regional and intraregional).

08/01900 Steam cracking and methane to olefins: energy use, CO_2 emissions and production costs

Ren, T. *et al. Energy*, 2008, 33, (5), 817–833.

While most olefins (e.g. ethylene and propylene) are currently produced through steam cracking routes, they can also possibly be produced from natural gas (i.e. methane) via methanol and oxidative coupling routes. Recent data were reviewed in the literature and then the energy use, CO_2 emissions and production costs of methane-based routes were compared with those of steam cracking routes. It was found that methane-based routes used more than twice as much process energy than state-of-the-art steam cracking routes (the energy content of products is excluded). The methane-based routes can be economically attractive in remote, gas-rich regions where natural gas is available at low prices. The development of liquefied natural gas may increase the prices of natural gas in these locations. Oxidative coupling routes are currently still immature due to low ethylene yields and other problems. While several possibilities for energy efficiency improvement do exist, none of the natural gas-based routes is likely to become more energy efficient or to lead to less CO_2 emissions than steam cracking routes do.

08/01901 The Spanish retail petroleum market: new patterns of competition since the liberalization of the industry

Bello, A. and Cavero, S. *Energy Policy*, 2008, 36, (2), 612–626.

This study considers the recent development of the Spanish automotive fuels market in the context of a long process of liberalization and competition. The aims are twofold. First, to overview the market's current patterns of competition, while taking into account the political, structural and strategic aspects that have marked the industry's recent evolution. Second, to study in depth one competitive strategy that nowadays significantly influences competition and final prices, the vertical relationships between operators and service stations. The analysis draws attention to several indicators that may demonstrate the success of the opening and liberalization process. Increased levels of competition have stimulated the sector's growth, development and modernization, and given national firms an excellent platform for competing with newcomers. Furthermore, studying the vertical agreements has produced interesting results. The authors have found that relative price differences among brands increase in line with perceived quality differences, and that the vertical separation of refineries and retailers eases price competition in the final market. The empirical evidence was backed up with a database of 4164 Spanish service stations.

08/01902 Using of cotton oil soapstock biodiesel–diesel fuel blends as an alternative diesel fuel

Keskin, A. *et al. Renewable Energy*, 2008, 33, (4), 553–557.

In this study, usability of cotton oil soapstock biodiesel–diesel fuel blends as an alternative fuel for diesel engines were studied. Biodiesel was produced by reacting cotton oil soapstock with methyl alcohol at determined optimum condition. The cotton oil biodiesel–diesel fuel blends were tested in a single cylinder direct injection diesel engine. Engine performances and smoke value were measured at full load condition. Torque and power output of the engine with cotton oil soapstock biodiesel–diesel fuel blends decreased by 5.8% and 6.2%, respectively. Specific fuel consumption of engine with cotton oil soapstock–diesel fuel blends increased up to 10.5%. At maximum torque speeds, smoke level of engine with blend fuels decreased up to 46.6%, depending on the amount of biodiesel. These results were compared with diesel fuel values.

Derived liquid fuels

08/01903 Additive effect of cobalt-exchanged coal on the liquefaction of subbituminous coal

Sugano, M. *et al. Fuel*, 2007, 86, (14), 2071–2075.

In comparison with the liquefaction (420 °C, with tetralin and elemental sulfur) of the proton-exchanged Adaro subbituminous coal with complex (metallocene or metal carbonyl) of cobalt, nickel or iron, the coal liquefaction was enhanced significantly on the liquefaction of cation (Co^{2+}, Ni^{2+} or Fe^{2+}) exchanged Adaro coal. However, for several kinds of subbituminous coal, metal cations hardly exchange due to the small content of carboxyl group in coal. Therefore, the simultaneous liquefaction of subbituminous coal and cobalt-exchanged coal were carried out in this study. Further, the simultaneous liquefaction of lower rank and subbituminous coals with $Co_2(CO)_8$ was carried out to compare the catalytic effect of cobalt derived from either the exchanged coal or $Co_2(CO)_8$. The catalytic effect of cobalt in the exchanged Morwell brown coal was appeared as the decrease of residue yield on the liquefaction with Yilan subbituminous coal. On the other hand, there was little enhancement on the simultaneous liquefaction of cobalt-exchanged Adaro and Yilan subbituminous coals. Accordingly, it is clarified that the hydroliquefaction of subbituminous coal, which was exchanged cation hardly, was enhanced by the addition of cobalt-exchanged brown coal.

08/01904 Compositional analysis of deasphalted oil before and after hydrocracking over zeolite catalyst by Fourier transform ion cyclotron resonance mass spectrometry

Miyabayashi, K. *et al. Fuel Processing Technology*, 2008, 89, (4), 397–405.

Elemental compositions of components in feed and catalytically processed deasphalted oils were characterized by Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS). The processed oils which were hydrocracked over a zeolite catalyst at three different reaction temperatures (370, 380, and 390 °C) were analysed. Species of the deasphalted oils were ionized either by electrospray ionization (ESI) or by in-beam electron ionization (EI). The ESI mass spectra were obtained from every feed and processed deasphalted oil. Over 550 chemically different compounds were observed in the feed oil mass spectra. Molecular formulas for the detected peaks were calculated by using accurate mass. The compounds with one N atom as well as one N and S atoms were detected as major and minor component, respectively, in every mass spectrum. The number of the detected species in processed deasphalted oil decreases as the reaction temperature increases. However, the carbon distribution of NS-containing species shifts to high number as the reaction temperature increases. Molecular formulas distribution against *Z*-value (*Z*-value is defined as $C_nH_{2n+Z}N_mS_sO_o$) and *C*-number were investigated for the ESI mass spectra. *Z*-value distribution of the peaks assigned to N-compounds was convergent in its compounds with $Z = -25$ as increasing the reaction temperature. Detailed mass spectrum analysis reveals that compounds which were not detected in the feed oil were observed in the mass spectra of processed oils; N, S, and O-containing compounds. For the in-beam EI only the processed oil at 390 °C yields approximately 700 resolved peaks at adopted probe temperature (300 °C) of EI. Molecular formula analysis for the observed peaks was conducted as well as ESI. It reveals that the molecular formulas having *Z*-value ($-30 < Z < 2$) and carbon number ranged from 8 to 31 except for ($-18 < Z < -12$, $15 < C\text{-number} < 22$) were contained in the processed deasphalted oil. Using complementary ionization techniques to characterize the feed and catalytic reacted deasphalted oils provide better understanding of fuel processing conditions.

08/01905 Diffusivity of coal and petroleum asphaltene monomers by fluorescence correlation spectroscopy

Guerra, R. E. *et al. Fuel*, 2007, 86, (12–13), 2016–2020.

Using fluorescence correlation spectroscopy the authors measured the translational diffusion coefficient of Iino coal asphaltenes and UG8 petroleum asphaltenes dispersed in toluene at extremely low concentrations (0.03–3.0 mg/L). Using a simple scaling argument the authors compared them with several molecules of known size and molecular weight. The study found that Iino coal asphaltene molecules – which have a comparatively small alkane fraction – have a diffusion constant of $1.5 \times 10^{-5}\,\text{cm}^2/\text{s}$ and corresponding hydrodynamic radius close to 0.25 nm: making them significantly smaller than petroleum asphaltenes.

08/01906 Evaluation of sulphonated acetone–formaldehyde (SAF) used in coal water slurries prepared from different coals

Qiu, X. *et al. Fuel*, 2007, 86, (10–11), 1439–1445.

A new type of water-soluble polymer, sulfonated acetone–formaldehyde resin (SAF), was developed as dispersant for the preparation of highly-loaded coal water slurry (CWS). In this study, in order to evaluate the practical use in industry, the SAF and a naphthalene sulfonate formaldehyde condensate are used to prepare CWS using four Chinese coals with different coalification degrees. The evaluation of the properties of CWS shows that SAF has better ability in reducing CWS viscosity at lower dosage than naphthalene sulfonate formaldehyde condensate, and that the CWS prepared from SAF has excellent stability within 48 h and exhibits shear-thinning apparent viscosity/shear rate behaviour at lower dosage. Based on the results, the SAF is an effective and promising dispersant for highly-loaded CWS.

08/01907 Methanolysis of triolein by low frequency ultrasonic irradiation

Hanh, H. D. *et al. Energy Conversion and Management*, 2008, 49, (2), 276–280.

Methanolysis of triolein was investigated at room temperature by 40 kHz ultrasonic irradiation to make biodiesel fuel as methyl esters. It was found that the yield of methyl esters strongly depended on the amount of KOH and the molar ratio of methanol to triolein (M/T) and was highest at the M/T molar ratio of 6/1, KOH concentration of 1 wt% and irradiation time of 30 min. In addition, the effects of sonication on the methanolysis of triolein were discussed in comparison to the effects of stirring experiments. The optimum condition under stirring experiments showed that the molar ratio of M/T, KOH concentration and reaction time were 6/1, 1.5 wt% and 4 h, respectively. These results clearly indicated that the ultrasonic irradiation method would be a promising one compared to the conventional stirring method. The high yield under the ultrasonic irradiation condition would be due to high speed mixing and mass transfer between the methanol and triolein as well as the formation of a microemulsion resulting from the ultrasonic cavitation phenomenon.

08/01908 The effect of additives on hydrodesulfurization of dibenzothiophene over bulk molybdenum sulfide: increased catalytic activity in the presence of phenol

Gül, Ö. *et al. Fuel Processing Technology*, 2008, 89, (4), 419–423.

The effect of various additive organic reagents on the activation of MoS_3 as molybdenum sulfide catalyst precursor during hydrodesulfurization reaction of dibenzothiophene was studied. It was found that the presence of phenol or 1-naphthol greatly promoted the activity of the catalyst, while tetralin, 9,10-dihydrophenanthrene, ethylbenzene, and pyridine reagents were found to be detrimental for the activity of the catalyst.

03 GASEOUS FUELS

Sources, properties, recovery, treatment

08/01909 Determination of multi-component gas and water equilibrium and non-equilibrium sorption isotherms in carbonaceous solids from early-time measurements

Jahediesfanjani, H. and Civan, F. *Fuel*, 2007, 86, (10–11), 1601–1613.

A rapid method is presented for determination of the multi-component gas and water sorption isotherms on carbonaceous solids from the non-equilibrium sorption data. This approach alleviates the long-time data requirement of the traditional volumetric gas adsorption technique used to construct gas isotherms requiring a series of equilibrium sorption measurements by successive pressure increments, particularly resorted in the coalbed methane industry. This is accomplished by the application of the non-equilibrium thermodynamics, multi-component material balance, gas sorption, and dissolution kinetic considerations for the gas adsorbed by carbonaceous solids and the gas dissolved in water under the effect of pressure, temperature, and grain size. The capabilities of the new technique in reducing the time required for construction of an isotherm are demonstrated by analysing a series of the non-equilibrium sorption measurements and projecting the results to the equilibrium case. Moreover, it is demonstrated that the present model enables constructing both the equilibrium and non-equilibrium multi-component gas and water sorption isotherms in any carbonaceous solids and particularly coals simultaneously in relatively shorter time and with higher accuracy.

08/01910 Investigation of glass transition temperatures of Turkish asphaltenes

Yasar, M. *et al. Fuel*, 2007, 86, (12–13), 1737–1748.

Asphaltenes are a major concern in production operations, due to their role in conversion of vacuum residues by processes such as coking, catalytic cracking and hydroconversion. Six Turkish asphaltenes were characterized by elemental content, proton NMR, carbon NMR, GPC, DSC. Differential scanning calorimetry (DSC) provides parameters for comparing the glass transition temperatures, endothermic behaviour of asphaltene and a hypothetical melting temperature of the asphaltenes which is within the range of the pyrolysis temperature of asphaltenes.

The glass transition temperatures points (T_g) of asphaltenes were determined using DSC. Hypothetical melting point temperature (T_m) of the asphaltenes was also calculated. Among all the asphaltenes tested, Bati Raman showed much higher glass transition temperatures than the others.

08/01911 Multi-component gas mixture diffusion through porous media: a 1D analytical solution

Pisani, L. *International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 650–660.

In this paper, the equations governing the transport of gas mixtures through porous media in 1D geometry and in absence of mass sources are examined. When the mass fluxes are determined by external conditions, the transport equations can be solved to find the variations of gas composition through the media. For this class of problems, it is shown that the convective transport mechanism can be, in many cases, neglected, regardless of the physical properties of the porous media and of the flux intensities. An estimate of the maximum error made in neglecting the convective term is provided. A matrix analytical solution of the diffusion equations is given for the general case of *N*-components gas mixtures. Explicit analytical solutions are derived in two particular cases.

Transport, storage

08/01912 CO_2 capture by adsorption with nitrogen enriched carbons

Plaza, M. G. *et al. Fuel*, 2007, 86, (14), 2204–2212.

The success of CO_2 capture with solid sorbents is dependent on the development of a low-cost sorbent with high CO_2 selectivity and adsorption capacity. Immobilized amines are expected to offer the benefits of liquid amines in the typical absorption process, with the added advantages that solids are easy to handle and that they do not give rise to corrosion problems. In this work, different alkylamines were evaluated as a potential source of basic sites for CO_2 capture, and a commercial activated carbon was used as a preliminary support in order to study the effect of the impregnation. The amine coating increased the basicity and nitrogen content of the carbon. However, it drastically reduced the microporous volume of the activated carbon, which is chiefly responsible for CO_2 physisorption, thus decreasing the capacity of raw carbon at room temperature.

08/01913 Influence of welding sequence on welding distortions in pipes

Sattari-Far, L. and Javadi, Y. *International Journal of Pressure Vessels and Piping*, 2008, 85, (4), 265–274.

This paper presents a three-dimensional thermo-mechanical analysis to investigate the effect of welding sequence on welding deformations in pipe–pipe joints of AISI stainless-steel type. Single-pass TIG welding with V-joint geometry in pipes having a diameter of 274 mm and a thickness of 6.2 mm is studied here. Nine different welding sequences are analysed. The finite element results are compared with experimental data. It has been shown that selecting a suitable welding sequence can substantially decrease the amount of welding distortions in this pipe geometry.

08/01914 Storage and the electricity forward premium

Douglas, S. and Popova, J. *Energy Economics*, 2008, 30, (4), 1712–1727.

In this paper, a model describing the influence of natural gas storage inventories on the electricity forward premium is developed and tested. The model is constructed by linking the effect of gas storage constraints on the higher moments of the distribution of electricity prices to an established model of the effect of those moments on the forward premium. The model predicts a sharply negative effect of gas storage inventories on the electricity forward premium when demand for electricity is high and space-heating demand for gas is low. Empirical results, based on PJM data, strongly support the model.

08/01915 Swelling of Australian coals in supercritical CO_2

Day, S. *et al. International Journal of Coal Geology*, 2008, 74, (1), 41–52.

An apparatus capable of directly observing, by an optical method, swelling of coal in CO_2 and other gases is described. The system was used to measure CO_2-induced swelling in three Australian bituminous coals at temperatures between 25 and 55 °C and pressures up to 15 MPa. All three coals showed similar behaviour, with swelling increasing as a function of pressure up to about 8 to 10 MPa, after which no further increase in swelling was observed. The maximum volumetric swelling was between about 1.7 and 1.9%, even in liquid CO_2. Significant anisotropy was observed; swelling in the plane perpendicular to the bedding plane was always substantially higher than in the parallel plane. The swelling in these coals was completely reversible with each sample returning to its original dimensions after the gas was removed, even after multiple exposures. Temperature did not directly affect the maximum amount of swelling, however, the swelling tended to occur at lower pressures with decreasing temperature. Expressing the swelling as a function of gas density rather than gas pressure showed that swelling was independent of temperature; in all cases the swelling curves were identical. Swelling could be well represented by a modified Dubinin–Radushkevich model which has been used previously to describe gas adsorption on coal. Volumetric swelling data for two of the coals were combined with gas adsorption results previously measured for these coals. Swelling was roughly proportional to the amount of CO_2 adsorbed up to intermediate pressures, but at high pressures, the relationship was no longer linear; adsorption continued to increase but swelling did not. The swelling data were used to correct the adsorption isotherm measured for these coals, assuming that the volume occupied by the coal was inaccessible to gas and increased in proportion to volumetric swelling. At pressures up to about 5 MPa, the effect of correction for swelling on the adsorption value was negligible but at higher pressures, the volume changes due to the swelling of the coal resulted in an increased measured excess adsorption. At 15 MPa the corrected excess sorption was about 30% greater than the uncorrected value. Correction for swelling had little effect on the calculated sorption capacity of the coal or the heat of sorption (using the modified Dubinin–Radushkevich equation) but had strong effects on the term representing dissolution of carbon dioxide into the coal.

08/01916 Temperature dependence of sorption of gases by coals and charcoals

Sakurovs, R. *et al. International Journal of Coal Geology*, 2008, 73, (3–4), 250–258.

Modelling the sorption properties of coals for carbon dioxide under supercritical conditions is necessary for accurate prediction of the sequestering ability of coals in seams. Recent data are presented for sorption curves of three dry Argonne Premium coals, for carbon dioxide, methane and nitrogen at two different temperatures at pressures up to 15 MPa. The sorption capacity of coals tends to decrease with increasing temperature. An investigation into literature values for sorption of nitrogen and methane by charcoal also show sorption capacities that decrease dramatically with increasing temperature. This is inconsistent with expectations from Langmuir models of coal sorption, which predict a sorption capacity that is independent of temperature. The isotherms were successfully fitted using a modified Dubinin–Radushkevich equation that uses gas density rather than pressure. A simple pore-filling model that assumes there is a maximum pore width that can be filled in supercritical conditions and that this maximum pore width decreases with increasing temperature, can explain this temperature dependence of sorption capacity. It can also explain why different supercritical gases give apparently different surface sorption capacities on the same material. The calculated heat of sorption for these gases on these coals is similar to those found for these gases on activated carbon.

08/01917 The welfare effects of unbundling gas storage and distribution

Breton, M. and Kharbach, M. *Energy Economics*, 2008, 30, (3), 732–747.

In this paper, a stylized gas system was used to study the use of access-to-gas storage in a seasonal model. In a duopoly setting, it is found that welfare is higher under vertical integration and open access organization than under separate management of storage and distribution. This raises questions about recent regulatory reforms in the gas sectors in the US and Europe, supporting the separation of storage and merchant activities. In the absence of other justifying reasons such as encouraging competition by creating a level playing field, separating the management and accounting functions of storage activities from those of distribution may be a better option than real divestiture, on the basis of welfare arguments.

Economics, business, marketing, policy

08/01918 A hydrogen economy and its impact on the world as we know it

Blanchette, S. *Energy Policy*, 2008, 36, (2), 522–530.

An assortment of governmental, technological, environmental, and economic factors has combined to spur renewed interest in alternatives to petroleum, and especially in hydrogen. While there is no clear consensus on the viability of the technology, governments and corporations alike have vigorous hydrogen research programs. The result is that hydrogen may stand on the verge of becoming a true successor to oil. A transition from oil to hydrogen would alter familiar global economic and political structures in profound ways. The ramifications will influence developed and developing nations, oil importers, and exporters alike. New alliances among governments, corporations, and other groups may challenge existing notions of governance. Although a hydrogen-based economy may be decades away, the vision for it requires near- and mid-term thinking to manage the transition smoothly. Further, hydrogen is only a metaphor; any change from the current oil economy will entail dramatic changes to the global status quo that must be planned for now.

08/01919 Electricity capacity expansion in Thailand: an analysis of gas dependence and fuel import reliance

Nakawiro, T. *et al. Energy*, 2008, 33, (5), 712–723.
Electricity generation in Thailand is highly dependent on natural gas. Recent research has revealed that the Thai economy would become more vulnerable from high gas dependence in the power sector. This paper aims to assess the economic impact of gas dependence in power generation in the coming decades. To fulfil this objective, two scenarios of electricity capacity planning were developed and the results were analysed to understand the changes in gas dependence and the effects on import reliance. It is found that from 2011 to 2025, the average cost of natural gas for power generation will account for 2.41% of gross domestic product (GDP) while high oil price in international energy markets would push this cost to 2.97% of GDP. In addition, reliance on fuel imports for power generation, particularly natural gas and coal, is going to be another crucial concern to the security of energy supply as the costs of these imports during the planning horizon will increase significantly at an average rate of 6.78% per year.

08/01920 How to reach a compromise on drilling in AWNR

Snyder, B. *Energy Policy*, 2008, 36, (3), 937–939.
Drilling in the Arctic National Wildlife Refuge (ANWR) has been controversial for decades and is likely to remain so. However, progress towards resolving this controversy might be possible if the US's congressional proposals to open ANWR include provisions that require the federal government to spend the money the federal government makes through leasing fees and taxes on conservation. The rising price of oil means that the profits to the federal government from drilling in ANWR are greater than the amount of money required to preserve all of the world's major centres of biodiversity. Moderate environmental organizations might therefore support drilling in order to avert other larger environmental problems elsewhere.

08/01921 Hydrocarbon potential of the Tuzgolu (Salt Lake) Basin, Central Anatolia, Turkey: a comparison of geophysical investigation results with the geochemical data

Aydemir, A. *et al. Journal of Petroleum Science and Engineering*, 2008, 61, (1), 33–47.
The Tuzgolu Basin is the largest interior basin in Central Anatolia, Turkey. Hydrocarbon exploration activities have been carried out in this basin since 1959. However, there is no commercial discovery recorded up to date. Seismic quality in the Tuzgolu Basin is very poor for accurate interpretation of the subsurface. Therefore, the basin was modelled three dimensionally (3-D) using the gravity data. According to the 3-D model map, the most important and deepest part of the basin is located 30–35 km to the southeast of the Aksaray city centre. This area is named as the Southern Aksaray Depression and has not been explored properly, because of the volcanic cover. In this study, all available geochemical data have been collected from reports of the Turkish Petroleum Corporation and previous published studies. All collected data have been classified according to the different geochemical parameters such as TOC, $S_1 + S_2$, $T_{\max}$, R_0 and SCI, and each parameter has been mapped regarding its maximum values. Afterwards, 3-D gravity modelling results have been compared to each geochemical map individually and it was observed that each parameter increases in value towards the Southern Aksaray Depression, and consequently, the 3-D model map is observed to be consistent to the geochemical maps. As a result of this consistency between the geophysical and geochemical maps, hydrocarbon exploration activities can be suggested in the prospective areas around the Southern Aksaray Depression in the future.

08/01922 Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries

Cologni, A. and Manera, M. *Energy Economics*, 2008, 30, (3), 856–888.
Sharp increases in the price of oil are generally seen as a major contributor to business cycle asymmetries. Moreover, the very recent highs registered in the world oil market are causing concern about possible slowdowns in the economic performance of the most developed countries. In this paper a structural cointegrated VAR model has been considered for the G-7 countries in order to study the direct effects of oil price shocks on output and prices, and the reaction of monetary variables to external shocks. The results can be summarized as follows: (i) a stationary money demand, as suggested by the classic theory of money, can be identified for most countries; (ii) according to the estimated coefficients of the structural part of the model, for all countries except Japan and UK the null hypothesis of an influence of oil prices on the inflation rate cannot be rejected. Inflation rate shocks are transmitted to the real economy by increasing interest rates; (iii) impulse response analysis suggests, for most countries, the existence of an instantaneous, temporary effect of oil price innovations on prices; (iv) impulse response functions indicate different monetary policy reactions to inflationary and growth shocks; (v) the simulation exercises directed to estimate the total impact of the 1990 oil price shock indicate that for some countries (USA) a significant part of the effects of the oil price shock is due to the monetary policy reaction function. For other countries (Canada, France and Italy), however, the total impact is offset, at least in part, by an easing of monetary conditions.

08/01923 Rhetoric versus reality: Russian threats to European energy supply

Goldthau, A. *Energy Policy*, 2008, 36, (2), 686–692.
European gas demand will rise from presently 540 billion cubic metres (bcm) to around 800 bcm in 2030. As more than 50% of overall European imports originate from Russia, fears have been expressed that the Kremlin could use energy resources as a foreign policy tool. A thorough assessment of domestic consumption, production and investment volumes however reveals that Russian supply will have difficulties in matching growing domestic and European demand. Hence, as the author argues, the threat to European gas supply does not lie in geopolitics, but rather in a lack of investment in the Russian upstream sector. Higher domestic Russian gas prices, enhanced energy efficiency and increases in non-Gazprom production would however make it possible for Russia to meet domestic demand and its export commitments for natural gas.

08/01924 Russian and European gas interdependence: could contractual trade channel geopolitics?

Finon, D. and Locatelli, C. *Energy Policy*, 2008, 36, (1), 423–442.
In a framework of international political economics, this article analyses the increasing distance between Russia and the European Union (EU) in their interdependent relationship with regard to gas. The representations of economic risks associated with the dominant position of the Russian seller in the European gas market are analysed in terms of industrial economics. Then the relevance of possible responses by the EU is analysed in relation to the reality of alleged risks of gas dependence: the tentative EU–Russia regulatory unification, the creation of a single gas negotiator, and the support to a denser pan-European network, with additional entry points and sources of supply and increased market integration in order to increase the contestability of the markets.

08/01925 Russian natural gas exports – will Russian gas price reforms improve the European security of supply?

Sagen, E. L. and Tsygankova, M. *Energy Policy*, 2008, 36, (2), 867–880.
Both theoretical and numerical tools are used to study the potential effects on Russian gas exports from different Russian domestic gas prices and production capacities in 2015. The authors also investigate whether a fully competitive European gas market may provide incentives for Gazprom, the dominant Russian gas company, to change its export behaviour. The main findings suggest that both increased domestic gas prices and sufficient production capacities are vital to maintain Gazprom's market share in Europe over the next decade. In fact, Russia may struggle to carry out its current long-term export commitments if domestic prices are sufficiently low. At the same time, if Russian prices approach European net-back levels, Gazprom may reduce exports in favour of a relatively more profitable domestic market.

08/01926 The asymmetric relationship between oil revenues and economic activities: the case of oil-exporting countries

Mehrara, M. *Energy Policy*, 2008, 36, (3), 1164–1168.
This paper examines the non-linear or asymmetric relationship between oil revenues and output growth in oil-exporting countries, applying a dynamic panel framework and two different measures of oil shocks. The main results in this paper confirm the stylized facts that in heavily oil-dependent countries lacking the institutional mechanisms de-linking fiscal expenditure from current revenue, oil revenue shocks tend to affect the output in asymmetric and non-linear ways. The findings suggest that output growth is adversely affected by the negative oil shocks, while oil booms or the positive oil shocks play a limited role in stimulating economic growth. The findings have practical policy implications for decision makers in the area of macroeconomic planning. The use of stabilization and savings funds and diversification of the real sector seems crucial to minimize the harmful effects of oil booms and busts.

08/01927 Valuing flexibility: the case of an integrated gasification combined cycle power plant

Abadie, L. M. and Chamorro, J. M. *Energy Economics*, 2008, 30, (4), 1850–1881.

In this paper, the choice between two technologies for producing electricity is analysed. In particular, the firm has to decide whether and when to invest either in a natural gas combined cycle (NGCC) power plant or in an integrated gasification combined cycle (IGCC) power plant, which may burn either coal or natural gas. Instead of assuming that fuel prices follow standard geometric Brownian motions, here they are assumed to show mean reversion, specifically to follow an inhomogeneous geometric Brownian motion. First, the authors consider the opportunity to invest in a NGCC power plant. The optimal investment rule is derived as a function of natural gas price and the remaining life of the right to invest. In addition, the analytical solution for a perpetual option to invest is obtained. Then the authors turn to the IGCC power plant. The valuation of an operating plant was analysed when there are switching costs between modes of operation, and the choice of the best operation mode. This serves as an input to evaluate the option to invest in this plant. Finally the authors derive the value of an opportunity to invest either in a NGCC or IGCC power plant, i.e. to choose between an inflexible and a flexible technology, respectively. Depending on the opportunity's time to maturity, the authors derive the pairs of coal and gas prices for which it is optimal to invest in NGCC, in IGCC, or simply not to invest. Numerical computations involve the use of one- and two-dimensional binomial lattices that support a mean-reverting process for coal and gas prices. Basic parameter values are taken from an actual IGCC power plant currently in operation. Sensitivity of some results with respect to the underlying stochastic process for fuel price is also checked.

Derived gaseous fuels

08/01928 Catalytic mechanism of sodium compounds in black liquor during gasification of coal black liquor slurry

Kuang, J.-P. *et al. Energy Conversion and Management*, 2008, 49, (2), 247–256.

The coal black liquor slurry (CBLS) was composed of coal and black pulping liquor, which has plenty of sodium compounds, lignin and cellulose. The sodium compounds have a catalytic effect on the gasification process of coal black liquor slurry, while lignin and cellulose enhance the heat value. Alkali-catalysed gasification experiments of CBLS and CWS (coal water slurry) are investigated on the thermobalance and fixed bed reactor. The residues of the gasification of CBLS and CWS are analysed by XRD, SEM and FT-IR. It is found that many micro- and mesopores and zigzag faces exist in the surface of the CBLS coke, which play a key role in the catalytic gasification. Sodium can enhance the reaction potential, weaken the bond of C–O and improve the gasification reaction rate. XRD results show that sodium aluminum silicate and nepheline are the main crystal components of the CBLS and CWS. The C–O stretching vibration peak in the $1060\,\mathrm{cm}^{-1}$ band in the CBLS shifts to $995.65\,\mathrm{cm}^{-1}$ in the CBLS coke after partial gasification. This means that the energy of the C–O stretching vibration in the CBLS carbon matrix decreases, so the structure of the carbon matrix is more liable to react with an oxygen ion or hydroxide ion. The amplitude of the C–O stretching vibration peak is augmented step by step due to the ground-excited level jump of the C–O band.

08/01929 Development and reactivity tests of Ce–Zr-based Claus catalysts for coal gas cleanup

Park, N.-K. *et al. Fuel*, 2007, 86, (14), 2232–2240.

The Claus reaction ($2H_2S + SO_2 \leftrightarrow 3/nS_n + 2H_2O$) was used to clean the gasified coal gas and the reactivity of several metal oxide-based catalysts on Claus reaction was investigated at various operating conditions. In order to convert H_2S contained in the gasified coal gas to elemental sulfur during Claus reaction, the catalysts having the high activity under the highly reducing condition with the moisture should be developed. CeO_2, ZrO_2, and $Ce_{1-x}Zr_xO_2$ catalysts were prepared for Claus reaction and their reactivity changes due to the existence of the reducing gases and H_2O in the fuel gas was investigated in this study. The Ce-based catalysts shows that their activity was deteriorated by the reduction of the catalyst due to the reducing gases at higher than 220 °C. Meanwhile, the effect of the reducing gases on the catalytic activity was not considerable at low temperature. The activities of all three catalysts were degraded on the condition that the moisture existed in the test gas. Specifically, the Ce-based catalysts were remarkably deactivated by their sulfation. The Ce–Zr-based catalyst had a high catalytic activity when the reducing gases and the moisture co-existed in the simulated fuel gas. The deactivation of the Ce–Zr-based catalyst was not observed in this study. The lattice oxygen of the Ce-based catalyst was used for the oxidation of H_2S and the lattice oxygen vacancy on the catalyst was contributed to the reduction of SO_2. ZrO_2 added to the Ce–Zr-based catalyst improved the redox properties of the catalyst in Claus reaction by increasing the mobility of the lattice oxygen of CeO_2.

08/01930 Effect of catalysts in the quality of syngas and by-products obtained by co-gasification of coal and wastes. 1. Tars and nitrogen compounds abatement

Pinto, F. *et al. Fuel*, 2007, 86, (14), 2052–2063.

The aim of this work is to analyse the possibility of using co-gasification technology to process coal mixed with wastes to take profit of its energy content and at the same time to minimize the environmental impact associated with the use of wastes and to diminish the costs of flue gas treatment. The addition to coal of different types of materials, like: pine-based waste, petcoke and polyethylene (PE), was not found to give rise to any operational problems, regarding both the feeding system and gasification process and led to higher energy conversions, however, the gas presented higher tars and hydrocarbons content. Several catalysts were tested, such as, dolomite, olivine, nickel and magnesium oxides, zinc oxides and cobalt and molybdenum oxides. Catalyst action was analysed in tars release and also in ammonia compounds reduction. The presence of catalysts allowed increasing hydrogen release, whilst there was a decrease in hydrocarbons and tars contents. A nickel–magnesium oxide was the catalyst that led to the highest reduction in hydrocarbons and tars. This catalyst also led to the lowest NH_3 content in the fuel gas produced, due to the catalyst efficiency in NH_3 destruction.

08/01931 Effect of fly ash and H_2S on a Ni-based catalyst for the upgrading of a biomass-generated gas

Albertazzi, S. *et al. Biomass and Bioenergy*, 2008, 32, (4), 345–353.

The main concern about the technology for the production of hydrogen and transport fuels by biomass gasification is the presence of contaminants (H_2S, tars, fly ash, alkali, and heavy metals, ammonia) that are poisonous for the catalysts used for upgrading the biomass-generated gas. The impact of the main contaminants on a Ni/MgAl(O) reforming catalyst was studied in a laboratory environment, by exposing the studied sample to H_2S, NH_3, K_2SO_4, KCl, $ZnCl_2$, and a solution derived from biomass fly ash. Lastly, the catalyst was also streamed with a gas produced by a bench-scale downdraft gasifier. The extent of deactivation was examined in the methane steam reforming reaction, under different operational conditions. The main effect of the treatments was a decrease in the bulk surface area and in the metal dispersion. Streaming H_2S quickly deactivated the catalyst; however, the activity was recovered by increasing the inlet temperature or by adding O_2 to the stream. In further laboratory tests, the performances of the catalyst seemed not to be greatly affected by either the above treatments or by the presence of ammonia in the fed water. The catalyst produced a syngas composition close to that predicted at equilibrium even after being streamed with the biomass-generated gas.

08/01932 Metal sorbents for high temperature mercury capture from fuel gas

Poulston, S. *et al. Fuel*, 2007, 86, (14), 2201–2203.

The authors have determined the Hg removal capacities of Pt and Pd supported on alumina at a range of different metal loadings from 2 to 9 wt% using Hg vapour in a simulated fuel gas feed. In the temperature range studied (204–388 °C) Pd proved far superior to Pt for Hg removal. The Hg removal capacity for both Pt and Pd increased with metal loading, though decreased with sorbent temperature. A shift in the 2θ position of the Pd XRD diffraction peak from 82.1 to 79.5 after Hg adsorption at 204 °C was consistent with the formation of a solid solution of Hg in Pd.

08/01933 Natural-gas-powered thermoelectricity as a reliability factor in the Brazilian electric sector

Fernandes, E. *et al. Energy Policy*, 2008, 36, (3), 999–1018.

The introduction of natural-gas-powered thermoelectricity into the Brazilian generation sector can be considered as a very complex energy, economic, regulatory and institutional revision. Brazil is a country with very specific characteristics in electricity generation, as approximately 80% of the generating capacity is based on hydroelectricity, showing strong dependency on rain and management of water reservoirs. A low rate of investment in the Brazilian Electricity Industry in the period of 1995–2000, associated with periods of low rainfall, led to a dramatic lowering of the water stocks in the reservoirs. With this scenario and the growing supply of natural gas, both from within Brazil and imported, natural gas thermal electric plants became a good option to diversify the electrical supply system. In spite of the Brazilian Government's efforts to install such plants, the country was faced with severe electricity rationing in 2001. The objective of this work is to show the need to continue with the implementation of natural gas thermal electricity projects, in a manner that allows flexibility and guarantees greater working reliability for the entire Brazilian electricity sector. Taking into account the world trend towards renewable energy, the perspectives of usage of biofuels in the Brazilian Energy Matrix and in electrical energy generation are also analysed. The very issue of electrical power efficiency in Brazil and its challenges and strategic proposals from the standpoint of Government Programs and results provided so far are presented. The technological constraints in order to put on stream the thermal electric plants are also analysed. The article concludes with a positive perspective of the usage of natural gas as to be the third pillar in the Brazilian Energy Matrix for the years to come.

08/01934 Numerical simulation of reactive transfers in spouted beds at high temperature: application to coal gasification

Mendes, A. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 117–128.

Spouted beds are used in many physical and chemical processes that involve large particles (drying, combustion, film deposition, gasification, etc.). Understanding of bed hydrodynamics, coupled heat and mass transfer and chemical reaction phenomena is mandatory for designing, scaling up and optimizing spouted beds. In this work, a spouted bed reactor operating at high temperature has been modelled through one-dimensional model in which heat transfer has been carefully described at different levels of complexity. The process of coal gasification has been selected to demonstrate the models achievements and predictions have been compared to previous spouted bed reactor experimental results. Calculations have shown that a particular attention must be paid to describe heat transfer in spouted bed reactors operating at high temperature.

08/01935 Two novel oxy-fuel power cycles integrated with natural gas reforming and CO_2 capture

Zhang, N. and Lior, N. *Energy*, 2008, 33, (2), 340–351.

Two novel system configurations were proposed for oxy-fuel natural gas turbine systems with integrated steam reforming and CO_2 capture and separation. The steam reforming heat is obtained from the available turbine exhaust heat, and the produced syngas is used as fuel with oxygen as the oxidizer. Internal combustion is used, which allows a very high heat input temperature. Moreover, the turbine working fluid can expand down to a vacuum, producing an overall high-pressure ratio. Particular attention was focused on the integration of the turbine exhaust heat recovery with both reforming and steam generation processes, in ways that reduce the heat transfer-related exergy destruction. The systems were thermodynamically simulated, predicting a net energy efficiency of 50–52% (with consideration of the energy needed for oxygen separation), which is higher than the Graz cycle energy efficiency by more than 2 percentage points. The improvement is attributed primarily to a decrease of the exergy change in the combustion and steam generation processes that these novel systems offer. The systems can attain a nearly 100% CO_2 capture.

08/01936 Wind energy potential in Tunisia

Elamouri, M. and Amar, F. B. *Renewable Energy*, 2008, 33, (4), 758–768.

The purpose of this paper is to constitute a database for the users of the wind power. It presents the study of 17 synoptic sites distributed on all the territory of Tunisia. From the meteorological data provided by the Meteorology National Institute, two statistical methods (meteorological and Weibull) are presented to evaluate the wind speed characteristics and the wind power potential at a height of 10 m above ground level and in an open area. An extrapolation of these characteristics with the height is also carried out. The results obtained give a global vision of the distribution of the wind potential in Tunisia and define the most windy zones.

LNG

08/01937 Optimizing liquefied natural gas terminal design for effective supply-chain operations

Özelkan, E. C. *et al. International Journal of Production Economics*, 2008, 111, (2), 529–542.

Liquefied natural gas (LNG) supply-chain management has become more critical due to the increased gas demand and the need for imported LNG. One of the major issues is the design of LNG terminals for efficient gas flow. This paper provides a framework for analysing the key design parameters for LNG terminals that impact profitability. Design considerations such as storage capacity, vessel docking capacity and throughput are taken into account and connected to the LNG sourcing using a mixed integer programming model. An application is provided for the Cove Point LNG Terminal in Maryland using a design of experiments framework.

08/01938 Real option valuation of free destination in long-term liquefied natural gas supplies

Rodríguez, R. Y. *Energy Economics*, 2008, 30, (4), 1909–1932.

This paper presents a real option model for the valuation of destination flexibility in long-term LNG supplies. Stochastic price dynamics in the different markets is modelled through geometric Brownian motion processes. Mean reversion is considered as well as correlation between markets, but instead of the usual correlation in return shocks, a price convergence term is introduced representing the arbitrage streams between markets. Model parameters are estimated from market data on LNG prices by maximum log-likelihood. The goodness of the fit for the proposed model is tested as well as for two alternative models. Confidence intervals for the parameters are given. Results for the model are calculated by Monte Carlo simulation. Frequency distributions for the main results are plotted. The effect of the main parameters of the model is studied (i.e. price volatilities, price convergence, initial prices in the markets, mean reversion, extra transportation costs, number of alternative markets). The value of destination flexibility is found to be an important share of the value of LNG.

Hydrogen generation and storage

08/01939 Amorphous cobalt–boron/nickel foam as an effective catalyst for hydrogen generation from alkaline sodium borohydride solution

Dai, H.-B. *et al. Journal of Power Sources*, 2008, 177, (1), 17–23.

Low cost and catalytically effective transition metal catalysts are of interest for the development of on-board hydrogen generation systems for fuel-cell vehicles. In the present study a modified electroless plating method was developed for the preparation of amorphous Co–B catalyst supported on Ni foam. Compared to the conventional electroless plating method, the newly developed method is more effective and produces Co–B catalyst with much higher catalytic activity. The catalytic activity of the supported Co–B catalyst was found to be highly dependent on the plating times and calcination conditions. Through optimization of these preparation conditions, the authors were able to prepare a catalyst capable of a hydrogen generation rate of $11\,l\,(\mathrm{min}\,g)^{-1}$ (catalyst) in a 20 wt.% $NaBH_4$ + 10 wt.% NaOH solution. Preliminary phase analyses and microstructure characterization were performed to understand the effects of preparation conditions on the catalytic activity of the Co–B catalyst.

08/01940 Continuous hydrogen evolution from cyclohexanes over platinum catalysts supported on activated carbon fibers

Tien, P. D. *et al. Fuel Processing Technology*, 2008, 89, (4), 415–418.

The continuous production of hydrogen from cyclohexanes is achieved effectively using Pt/ACF (activated carbon fibre) catalysts in a fixed-bed flow reactor. The Pt catalysts are more effective than a Pd/ACF catalyst for the reaction. Besides cyclohexane, methylcyclohexane, 1,4-dimethylcyclohexane, and *p*-menthane can also be employed as hydrogen source in the reaction system.

08/01941 Current status of combined systems using alkaline fuel cells and ammonia as a hydrogen carrier

Hejze, T. *et al. Journal of Power Sources*, 2008, 176, (2), 490–493.

In order to solve the hydrogen storage problem ammonia is considered as a storage compound. Hydrogen is supplied by a cracking process. According to equilibrium conditions traces of ammonia are expected, which are known to negatively affect PEM-based fuel cells. Experiments with alkaline fuel cells were carried out. No negative effects on the cell performance were found, when the feed gas contained low concentrations of ammonia.

08/01942 Customized design for the ejector to recirculate a humidified hydrogen fuel in a submarine PEMFC

Kim, M. *et al. Journal of Power Sources*, 2008, 176, (2), 529–533.

The customized design of an anode recirculation system that uses an ejector based on the humidified hydrogen is proposed for a submarine PEMFC. Generally, the ejector is useful to enhance its system performance and to easily be operated and maintained since it does not require any parasitic power and has very simple structure. However, the existing commercial ejectors do not meet the practical operating requirements of the PEMFC system with the humidified hydrogen recirculation since the included water raises the ejector performance reduction and accompanying operating limits. The subsonic flow ejector designed by the proposed approach has met the desired entrainment ratio through the whole operating range of the target system as well as it allows the additional advantages to improve the system efficiency and simplicity and to overcome the conventional operating limits.

08/01943 Hydrogen production from glycerin by steam reforming over nickel catalysts

Adhikari, S. *et al. Renewable Energy*, 2008, 33, (5), 1097–1100.

Increasing biodiesel production has resulted in a glut of glycerin that has led to a precipitous drop in market prices. In this study, the use of glycerin as a biorenewable substrate for hydrogen production, using a steam reforming process, has been evaluated. Production of hydrogen from glycerin is environmentally friendly because it adds value to this byproduct generated from biodiesel plants. The study focuses on nickel-based catalysts with MgO, CeO_2, and TiO_2 supports. Catalysts were characterized with thermogravimetric analysis and X-ray diffraction techniques. Maximum hydrogen yield was obtained at 650 ° C with MgO supported catalysts, which corresponds to 4 mol of H_2 out of 7 mol of stoichiometric maximum.

08/01944 Progress in high-power nickel–metal hydride batteries

Bäuerlein, P. *et al. Journal of Power Sources*, 2008, 176, (2), 547–554.

High demands to power performance, high cycle and calendar life as well can be met by NiMH batteries, making this battery system very suitable for HEV applications. The hydrogen storage alloy plays an important role with respect to power performance and life duration. Power performance and cycle life behaviour are related to each other by the electrochemical and mechanical properties of the alloy, via a more or less reciprocal relationship. In terms of power performance at medium-discharge rates, the charge transfer reaction at the hydrogen storage alloy interface was found to be crucial for the temperature-dependent behaviour of the cell, whereas at discharge rates above about $15C$ diffusion limitation was found especially at the negative electrode. The alloy corrosion is taking place in alkaline media, leading to the formation of surface films and a change of the chemical composition, especially in near surface regions of the alloy particles. Consecutive electrochemical cycles lead to mechanical stress and finally cracking of the alloy particles. Stability against corrosion and pulverization on one hand and good electrochemical performance on the other hand both depend on the chemical composition of the alloy, its morphological properties and the cycling regime used.

08/01945 Thermochemical two-step water splitting by ZrO_2-supported $Ni_xFe_{3-x}O_4$ for solar hydrogen production

Kodama, T. *et al. Solar Energy*, 2008, 82, (1), 73–79.

A thermochemical two-step water-splitting cycle using a redox metal oxide was examined for Ni(II) ferrites or $Ni_xFe_{3-x}O_4$ $(0 \le x \le 1)$ for the purpose of converting solar high-temperature heat to hydrogen. The Ni(II) ferrite was decomposed to Ni-doped wustite ($Ni_yFe_{1-y}O$) at 1400 °C under an inert atmosphere in the first thermal-reduction step of the cycle; it was then reoxidized with steam to generate hydrogen at 1000 °C in the second water-decomposition step. Although non-doped Fe_3O_4 powders formed a nonporous, dense mass of iron oxide by the fusion of FeO and its subsequent solidification after the thermal-reduction step, Ni(II)–ferrite powders were converted into a porous, soft mass after the step. This was probably because Ni doping in the FeO phase raised the melting point of wustite above 1400 °C. Supporting the Ni(II) ferrites on m-ZrO_2 (monoclinic zirconia) alleviated the high-temperature sintering of iron oxide; as a result, the supported ferrites exhibited greater reactivity and assisted the repeatability of the cyclic water splitting process as compared to the unsupported ferrites. The reactivity increased with the doping value x, and was maximum at $x = 1.0$ in the $Ni_xFe_{3-x}O_4/m\text{-}ZrO_2$ system.

08/01946 Thermodynamic possibilities and constraints for pure hydrogen production by a nickel and cobalt-based chemical looping process at lower temperatures

Svoboda, K. *et al. Energy Conversion and Management*, 2008, 49, (2), 221–231.

The reduction of nickel and cobalt oxides by hydrogen, CO, CH_4 and model syngas (mixtures of $CO + H_2$ or $H_2 + CO + CO_2$) and oxidation by water vapour has been studied from the thermodynamic and chemical equilibrium points of view. Attention was concentrated not only on convenient conditions for reduction of the relevant oxides to metals at temperatures in the range 400–1000 K, but also on the possible formation of undesired soot, carbides and carbonates as precursors for carbon monoxide and carbon dioxide formation in the steam oxidation step. Reduction of nickel and cobalt oxides (NiO, CoO and Co_3O_4) by hydrogen or CO at such temperatures is feasible. The oxidation of Ni and Co by steam and simultaneous production of hydrogen is thermodynamically the more difficult step at temperatures of 400–900 K. For the Ni–NiO and Co–CoO systems, the formation of corresponding Ni/Co–ferrite or Ni/Co aluminum spinel could be used for a higher hydrogen equilibrium yield. Only such Ni–NiO and Co–CoO systems with the support of ferrite and aluminium spinel formation could be suitable systems for chemical looping production of hydrogen by the chemical looping redox process. Oxidation of mixed Ni/Co–Fe metals or alloys by steam without segregation caused by preferential oxidation of Fe is critical for the ferrites. For processes based on Ni/Co aluminum spinel, reduction to metals is the critical part of the cyclic process. Under strongly reducing conditions, at high CO concentrations/pressures, formation of nickel carbide (Ni_3C) before cobalt carbide Co_2C is thermodynamically favored. Pressurized conditions during the reduction step with CO/CO_2 containing gases enhance the formation of soot and carbon containing carbide and/or carbonate compounds.

04 BY-PRODUCTS RELATED TO FUELS

08/01947 Activated carbon from broiler litter: process description and cost of production

Lima, I. M. *et al. Biomass and Bioenergy*, 2008, 32, (6), 568–572.

Animal manure continues to represent a significantly large and problematic portion of the US agricultural waste generated yearly. Granular activated carbons made from pelletized poultry litter have been shown to adsorb various positively charged metal ions from laboratory-prepared solutions. The objective of this study was to develop a conceptual capital and operating cost estimate using the Superpro Designer process simulation program. In the study, it was assumed that the activated carbon manufacturing facility obtains the poultry litter from various farmers at a cost of \$5.50 and \$27.50 t^{-1} for transportation. The carbon manufacturing facility processes 20 t of poultry litter per day and converts it into granular activated carbon for a final carbon yield of 21.6% (dry basis). This facility operates continuously, 330 days of the year. Several parameters were incorporated in the study including equipment sizing, capital costs and operating costs, such as labor, utilities, maintenance and equipment depreciation. The largest contributor to the cost of producing the activated carbon is the \$1,200,000 equipment cost of the combined pyrolysis/activation furnace, which contributes about \$0.47 kg^{-1} to the production cost. This study indicates that activated carbon can be produced by this method at a cost of about \$1.44 kg^{-1}.

08/01948 Assessment of metal mobility in MSW incineration ashes using water as the reagent

Karlfeldt, K. and Steenari, B.-M. *Fuel*, 2007, 86, (12–13), 1983–1993.

In this work, the methodology for quantification of water-soluble species in ash was evaluated by varying the parameters leaching time, liquid-to-solid ratio, and size reduction by grinding. The basis for the methodology is a modification of Tessier's sequential extraction method. This work concentrated on fly ashes from combustion of MSW in a fluidized bed boiler, and generally the amounts of water-soluble forms of metals in the ashes were low. Longer leaching time generally reduced the amount of water-soluble metal detected, showing the importance of adsorption and re-precipitation processes. The effects of the L/S parameter and of grinding seem to be dependent on the characteristics of the ash matrix.

08/01949 Combustion reactivity of different oil-fired fly ashes as received and leached

Seggiani, M. *et al. Fuel*, 2007, 86, (12–13), 1885–1891.

The combustion of heavy fuel oil for power generation leads to a great production of fly ashes, usually disposed of in controlled expensive landfills. As possible alternatives to their conventional disposal, hydrometallurgical processes are used for the recovery of valuable metals such as vanadium and nickel and the carbonaceous residues, so obtained, could be burned to recover energy. In this study, the combustion of oil-fired fly ashes, as received and leached, was investigated by thermo-analysis in atmospheres at different oxygen concentration (6, 12 and 21 vol%). Two commercial coals were used as reference samples. The ignition temperature and the thermo-kinetic analysis were used to compare the reactivity of the different samples. Besides, in order to value the feasibility of co-combustion of leached fly ashes with coals in pre-existent coal boilers, blends of leached fly ash with coal were prepared and their combustion behaviour was investigated.

08/01950 Comparing metal leaching and toxicity from high pH, low pH, and high ammonia fly ash

Palumbo, A. V. *et al. Fuel*, 2007, 86, (10–11), 1623–1630.

Previous work with both class F and class C fly ash indicated minimal leaching from most fly ashes tested. However, the addition of NO_x removal equipment might result in higher levels of ammonia in the fly ash. The authors have recently been testing fly ash with a wide range of pH (3.7–12.4) originating from systems with NO_x removal equipment. Leaching experiments were done using dilute $CaCl_2$ solutions in batch and columns and a batch nitric acid method. All methods indicated that the leaching of heavy metals was different in the highest ammonia sample tested and the high pH sample. However, toxicity testing with the Microtox system has indicated little potential toxicity in leachates except for the fly ash at the highest pH (12.4). When the leachate from the high pH fly ash was neutralized, toxicity was eliminated.

08/01951 Mercury and selenium retention in fly ashes: Influence of unburned particle content

López-Antón, M. A. *et al. Fuel*, 2007, 86, (14), 2064–2070.

Mercury and selenium are present as trace elements in coal and may be emitted to the environment in gas phase during coal conversion processes or be partially retained on the fly ashes. The present work explores the possibility that selenium may contribute to mercury capture in fly ashes in two different situations: firstly the power station itself, in order to evaluate the influence of typical working conditions, and secondly in a fixed bed of fly ashes enriched with Se, in order to study the capture of mercury in more severe conditions. It was found that the presence of selenium in fly ashes may improve their capacity to capture mercury. However, in the four fly ashes of different origin studied, selenium is not the most important component for mercury retention. In fact, the presence of selenium in fly ash samples enriched in unburned carbon does not have any significant effect on mercury retention.

08/01952 Synthesis of granular zeolitic materials with high cation exchange capacity from agglomerated coal fly ash

Juan, R. *et al. Fuel*, 2007, 86, (12–13), 1811–1821.

Fly ash from coal combustion is a potential source of pollution and there is continuous interest in its recycling by converting it into products such as zeolitic materials for use in retaining pollutants. In this paper, production of granular zeolitic material from a commercially unusable fine-fraction of a lightweight aggregate (LA) building material made from coal fly ash agglomerated with lime, by conventional alkaline activation is described. NaP1 zeolite, K-F zeolite, K-Phillipsite and K-Chabazite were synthesized. The process was optimized by combining four reaction parameters (temperature, alkali concentration, solution/fly ash ratio and reaction time). Zeolitic materials with the highest zeolite yields and cation exchange capacities were selected for future application in environmental processes. End-product zeolitic materials maintain its granular form and this could favour their use in some particular applications for environmental waste treatment (e.g. ionic exchange in column) without any further transformation stages.

05 NUCLEAR FUELS

Scientific, technical

08/01953 A polymer solution technique for the synthesis of nano-sized Li_2TiO_3 ceramic breeder powders

Jung, C.-H. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 194–198.

Nano-sized Li_2TiO_3 powder was fabricated by an organic–inorganic solution route. A steric entrapment route employing ethylene glycol was used for the preparation of the nano-sized Li_2TiO_3 particles. Titanium isopropoxide and lithium nitrate were dissolved in liquid-type ethylene glycol without any precipitation. With the optimum amount of the polymer, the metal cations (Li and Ti) were dispersed in the solution and a homogeneous polymeric network was formed. The organic–inorganic precursor gels were turned to crystalline powders through an oxidation reaction during a calcination process. The dried precursor gel showed the carbon-free Li_2TiO_3 crystalline form which was observed above 400 °C. The primary particle size of the carbon-free Li_2TiO_3 was about 70 nm, and the structure of the crystallized powder was porous and agglomerated. The powder compact was densified to 92% of TD at a relatively low sintering temperature of 1100 °C for 2 h.

08/01954 An extension of the two-zone method for evaluating a fission gas release under an irradiation-induced resolution flux

Cheon, J.-S. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 280–288.

This paper describes an extension of the adaptive two-zone method whose accuracy is substantially enhanced when compared to the original formulation by Matthews and Wood. A diffusive problem under the presence of an irradiation-induced resolution flux is evaluated by applying a variational principle to the diffusion equation. Prior to a gas saturation in the grain boundaries, a constraint associated with a gas balance is added to the variational equation. The spherical grain is divided into two regions whose interface is relocated as the ratio of the number of gas atoms within a grain to that generated. The distribution of the gas concentration is calculated over the grain. During the calculations, the number of degrees of freedoms is reduced to provide a profile which decreases monotonically along the radius. Numerical verifications show that the present approach is viable in computing a gas release accurately and efficiently in fuel performance codes.

08/01955 Conjugate conduction-forced convection heat transfer analysis of a rectangular nuclear fuel element with non-uniform volumetric energy generation

Ramis, M. K. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 517–525.

The main objective of this paper is to present a comparative study of uniform and non-uniform volumetric energy generation in a rectangular nuclear fuel element washed by upward moving stream of liquid sodium. Employing finite difference schemes, the boundary layer equations governing the flow and thermal fields in the fluid domain are solved simultaneously with two-dimensional energy equation in the solid domain by satisfying the continuity of temperature and heat flux at the solid–fluid interface. Numerical results are presented for a wide range of aspect ratio, A_r, conduction–convection parameter, N_{cc}, total energy generation parameter, Q_t, and flow Reynolds number, Re_H. It is concluded that for the same total energy generation, a somewhat realistic non-uniform volumetric energy generation puts greater restriction on the thermal power generation as compared to the idealistic uniform volumetric energy generation. Further, it is found that despite the total energy generation being the same for two cases, the non-uniform volumetric energy generation within the fuel element results in considerably higher energy dissipation rate.

08/01956 Control, data acquisition, data analysis and remote participation in LHD

Nagayama, Y. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 170–175.

This paper presents the control, data acquisition, data analysis and remote participation facilities of the large helical device (LHD), which is designed to confine the plasma in steady state. In LHD the plasma duration exceeds 3000 s by controlling the plasma position, the density and the ICRF heating. The 'LABCOM' data acquisition system takes both the short-pulse and the steady-state data. A two-layer mass storage system with RAIDs and Blu-ray disk jukeboxes in a storage area network has been developed to increase capacity of storage. The steady-state data can be monitored with a web browser in real time. A high-level data analysis system with web interfaces is being developed in order to provide easier usage of LHD data and large FORTRAN codes in a supercomputer. A virtual laboratory system for the Japanese fusion community has been developed with multi-protocol label switching virtual private network technology. Collaborators at remote sites can join the LHD experiment or use the NIFS supercomputer system as if they were working in the LHD control room.

08/01957 Determination of critical fracture energy, G_{fr}, from crack tip stretch

Dhar, S. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (5), 313–321.

Characterization of ductile fracture is a major problem, especially in the nuclear industry where the material behaviour in the upper shelf region is important. Use of the J–Δa curve to cover the risk of ductile fracture is popular among the designers. But, it is well known that the J–Δa curve can be geometry dependent, so, transfer of laboratory test data to the components is a problem. Serious attempts have been made in the recent past to identify a unique material function (independent of geometry) to characterize ductile fracture. Those attempts are partly successful, but there are still many aspects to be solved. The present work aims at the same direction as mentioned above. The paper has three distinct parts, namely a theoretical model, FE simulation and discussions on FE-simulated results. In the theoretical model attempts have been made to relate critical fracture energy, G_{fr}, with crack tip deformation (stretch) by using the final stretch theory of Michael Wnuk together with a cohesive traction–separation model. The objective of this model is to extract G_{fr} from local deformation of the crack tip so as to identify it as a crack growth parameter. Next, this model has been successfully implemented in FE simulation of CT specimens and TPBB specimens of ductile materials. G_{fr} is obtained from the local crack tip stretch together with other associated results. Finally, the results obtained from FE simulation are analysed. It is found that G_{fr} is a fracture parameter connected to crack tip deformation and it can simulate ductile crack growth process in a steady-state condition.

08/01958 Development of a new decay heat removal system for a high temperature gas-cooled reactor

Sim, Y. S. *et al. Annals of Nuclear Energy*, 2007, 34, (10), 803–812.

The heat removal capacity of a RCCS is one of the major parameters limiting the capacity of a HTGR based on a passive safety system. To improve the plant economy of a HTGR, the decay heat removal capacity needs to be improved. For this, a new analysis system of an algebraic method for the performance of various RCCS designs was set up and the heat transfer characteristics and performance of the designs were analysed. Based on the analysis results, a new passive decay heat removal system with a substantially improved performance, LFDRS was developed. With the new system, one can have an expectation that the heat removal capacity of a HTGR could be doubled.

08/01959 Development of CAP process for fabrication of ThO_2–UO_2 fuels part I: fabrication and densification behaviour

Kutty, T. R. G. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 299–308.

The coated agglomerate pelletization (CAP) process is a novel and innovative technique for the fabrication of (Th, ^{233}U) mixed oxide fuel pellets. This technique is being investigated to fabricate the fuel for the forthcoming Indian advanced heavy water reactor (AHWR). In the CAP process, ThO_2 is converted to free flowing agglomerate by powder extrusion route. As only ThO_2 is handled to this stage, all the operations are carried out in a normal glove-box facility. Subsequent operations are carried out in a shielded glove-box or hot cell facility using manipulators. In this study, fabrication of ThO_2–4%UO_2 and ThO_2–20%UO_2 (all compositions are in weight percent) pellets was carried out by CAP process. For having these ThO_2–UO_2 pellets, ThO_2 granules and U_3O_8 powders were used as the starting materials. The densification behaviour of the pellets was studied in reducing and oxidizing atmospheres using a high temperature dilatometer. The microstructure was examined by optical microscopy, scanning electron microscopy and electron probe microanalysis.

08/01960 DIII-D Integrated plasma control solutions for ITER and next-generation tokamaks

Humphreys, D. A. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 193–197.

Plasma control design approaches and solutions developed at DIII-D to address its control-intensive advanced tokamak mission are applicable to many problems facing ITER and other next-generation devices. A systematic approach to algorithm design, termed 'integrated plasma control,' enables new tokamak controllers to be applied operationally with minimal machine time required for tuning. Such high confidence plasma control algorithms are designed using relatively simple ('control-level') models validated against experimental response data and are verified in simulation prior to operational use. A key element of DIII-D integrated plasma control, also required in the ITER baseline control approach, is the ability to verify both controller performance and implementation by running simulations that connect directly to the actual plasma control system (PCS) that is used to operate the tokamak itself. The DIII-D PCS comprises a powerful and flexible C-based realtime code and programming infrastructure, as well as an arbitrarily scalable hardware and realtime network architecture. This software infrastructure provides a general platform for implementation and verification of realtime algorithms with arbitrary complexity, limited only by speed of execution requirements. A complete suite of tools is presented (known collectively as TokSys) supporting the integrated plasma control design process, along with recent examples of control algorithms designed for the DIII-D PCS. The use of validated physics-based models and a systematic model-based design and verification process enables these control solutions to be directly applied to ITER and other next-generation tokamaks.

08/01961 Evolution of mechanical properties of SiC under helium implantation

Tromas, C. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 142–149.

Mechanical property changes of 4H–SiC implanted at room temperature with helium ions at fluences ranging from 7×10^{15} to $1 \times 10^{17}\,cm^{-2}$ and at an ion energy of 50 keV were investigated by using nanoindentation tests and subsequent atomic force microscopy investigations. Degradation of the mechanical properties of the near-surface due to helium implantation was analysed and correlated with the microstructure evolution examined through transmission electron microscopy cross-section and X-ray diffraction experiments. Up to $1 \times 10^{16}\,He^{+}\,cm^{-2}$ no significant change in mechanical properties is seen whereas a normal strain profile of few percents is generated all along the ion path. Nevertheless, the as-created implantation damage enhance the dislocation nucleation. At intermediate fluences, when a buried amorphous layer is created, the hardness curve against penetration depth can be divided into three stages showing 'constraining coating' effects. When the entire part of the implanted crystal is amorphous a decrease of about 50% is measured for hardness value.

08/01962 Finite element analyses and verifying tests for a shock-absorbing effect of a pad in a spent fuel storage cask

Kim, D. Ha *et al. Annals of Nuclear Energy*, 2007, 34, (11), 871–882.

A spent fuel storage cask is required to prove the safety of its canister under a hypothetical accidental drop condition which means that the canister is assumed to be free dropped on to a pad of the storage cask during the loading of the canister into a storage cask. In this paper, finite element analyses and verifying tests for a shock-absorbing effect of a pad in a spent fuel dry storage cask were carried out to improve the structural integrity of the canister under a hypothetical accidental drop condition. The pad of the storage cask was originally designed as cylindrical steel structure filled with concrete. The pad was modified by using the structure composed of steel and polyurethane-foam instead of the quarter of the upper concrete as an impact limiter. The effects of the shape and the thickness of the steel structure and the density of the polyurethane-foam which was used in between steel structures were studied. As the optimized pad of a spent fuel dry storage cask, the quarter of the upper concrete was replaced with 12 mm thick circular steel structure and polyurethane-foam whose density was 85 kg/m^3. The drop tests of a third-scale model for the canister on to the original pad and the optimized pad were conducted. The effect of the pad structure was evaluated from the drop tests. The optimized pad has a greater shock-absorbing effect than the original pad. In order to verify the analysis results, strains and accelerations in the time domain by the analytical methods were compared with those by a test. The numerical method of simulating the free drop test for a dry storage cask was verified and the numerical results were found to be reliable.

08/01963 Gas fueling system in LHD

Miyazawa, J. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 265–268.

Gas fueling is the basic method of plasma density control for thermonuclear fusion devices. It outperforms other fueling methods with respect to ease of steady state operation by density feedback control, ease of handling, low costs for both construction and maintenance, and flexibility in working gas selection. The gas fueling system of the large helical device is composed of gas cylinders, gas purifiers, gas reserve tanks, vacuum pumps, and pressure gauges. Hydrogen, helium, neon (or methane), argon, and xenon (or krypton, or helium-3) are regularly filled in the gas reserve tanks. These gases are injected to the vacuum vessel through 'mass flow controllers (MFCs)' and/or 'piezo-electric valves (PVs)'. The MFC feedback controls the flow rate to the preordered value. The PV is driven by preprogrammed mode or density feedback mode. The flow rates of PVs are calibrated in situ. All components in the system are directly controlled by a programmable logic controller, which is connected to a private local area network. Users can control the system from personal computers through the network. The graphical user interface for system control and that for setting waveforms to drive PVs are working on MS Windows.

08/01964 Neutron irradiation effect on site distribution of cations in non-stoichiometric magnesium aluminate spinel

Sawabe, T. and Yano, T. *Journal of Nuclear Materials*, 2008, 373, (1–3), 328–334.

Neutron irradiation effects on cation distribution in non-stoichiometric Mg–Al spinel were examined by atom location by channeling enhanced microanalysis method. Parameter n, or non-stoichiometry of $MgO \cdot nAl_2O_3$ of the specimens, were $n = 1.00$, 1.01, 1.10, 1.48. These specimens were neutron-irradiated up to a fluence of $2.3 \times 10^{24}\,n/m^2$ ($E > 0.1$ MeV) at 500–530 °C in JMTR. Some specimens contracted by the irradiation and the arrangement of cations became more disorder. The other specimens showed very small swelling by the irradiation and the cation distribution became slightly ordered. The cation distribution of the contracted specimen returned stepwise to the pre-irradiated condition after the annealing at 700 °C. The cation distribution of the slightly swollen specimens did not change after the annealing up to 700 °C. Cation distribution in the T-site was more sensitively influenced by the irradiation.

08/01965 Radiation exergy: the case of thermal and nuclear energy

Isvoranu, D. and Badescu, V. *International Journal of Nuclear Governance, Economy and Ecology*, 2008, 2, (1), 90–112.

This study presents several methods to evaluate the exergy of thermal and nuclear radiation. First, a general treatment is developed for the thermal radiation exergy flux. Second, the exergy of thermal radiation is derived from a simple, general, original thermodynamic argument.

Third, the state of the art concerning the accurate upper bounds for the conversion efficiency of thermal radiation into work is briefly presented. Fourth, the exergy of nuclear radiation is derived.

08/01966 Research and development of fusion grid infrastructure based on atomic energy grid infrastructure (AEGIS)

Suzuki, Y. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 511–515.

In collaboration with the Naka Fusion Institute of Japan Atomic Energy Agency (NFI/JAEA) and the National Institute for Fusion Science of National Institute of Natural Science (NIFS/NINS), Center for Computational Science and E-systems of Japan Atomic Energy Agency (CCSE/JAEA) aims at establishing an integrated framework for experiments and analyses in nuclear fusion research based on the atomic energy grid infrastructure (AEGIS). AEGIS has been being developed by CCSE/JAEA aiming at providing the infrastructure that enables atomic energy researchers in remote locations to carry out R&D efficiently and collaboratively through the Internet. Toward establishing the integrated framework, the authors have been applying AEGIS to pre-existing three systems: experiment system, remote data acquisition system, and integrated analysis system. For the experiment system, the secure remote experiment system with JT-60 has been successfully accomplished. For the remote data acquisition system, it will be possible to equivalently operate experimental data obtained from LHD data acquisition and management system (LABCOM system) and JT-60 data System. The integrated analysis system has been extended to the system executable in heterogeneous computers among institutes.

08/01967 Safety assessment of austenitic steel nuclear power plant pipelines against stress corrosion cracking in the presence of hybrid uncertainties

Anoop, M. B. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (4), 238–247.

Stress corrosion cracking (SCC) is an important degradation mechanism to be considered for safety assessment of nuclear piping components made of austenitic steels, especially in the heat-affected zones. Damage due to SCC occurs in a susceptible material, in a corrosive environment, in the presence of high temperature and high applied/residual stresses. The operating conditions and the environmental conditions show variations during the lifetime of the power plant. Also, there will be variations in micro-structural properties of the material of piping components. These variations should be taken into account while assessing the safety of the piping component against SCC. This can be accomplished by treating the relevant variables as random or fuzzy depending upon the source and type of uncertainty. In this paper, an attempt has been made to compute the fuzzy failure probabilities of a piping component against SCC with time, using an approach combining the vertex method with the Monte Carlo simulation technique. The initiation and propagation stages of stress corrosion cracks are modelled using a modified PRAISE approach. The degree of sensitization, material fracture toughness, yield strength, ultimate strength and applied stress are considered as random variables, while operating temperature and oxygen concentration are considered as fuzzy variables. The R6 procedure is used in the computation of the fuzzy failure probabilities. The usefulness of the approach is demonstrated through an example problem.

08/01968 The JET PCU project: an international plasma control project

Sartori, F. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 202–206.

This paper describes the new JET enhancement project ‘plasma control upgrade’. Initially aimed at an overhaul of JET plasma control capabilities it was eventually focused on improving the vertical stabilization (VS) system ability to recover from large edge localized mode perturbations. The paper describes the results of the first two years where the activity was aimed principally at researching a solution that could be implemented within the timing and budget constraints. A very important task was that of improving the modelling of JET plasma, iron core and passive structures. Using dedicated experiments, the models were progressively refined until it was possible not just to explain the experimental data but predict the VS system behaviour. At the same time the project team studied the best options for power supply and control system upgrades and evaluated whether a change of turns in the stabilization coil was desirable and possible. A new fast radial field power supply is now being ordered and the VS control system is being upgraded.

08/01969 Thermal-hydraulic modeling of reactivity accident in MTR reactors

Khater, H. *et al. Annals of Nuclear Energy*, 2007, 34, (9), 732–742.

This paper describes the development of a dynamic model for the thermal-hydraulic analysis of MTR research reactor during a reactivity insertion accident (RIA). The model is formulated for coupling reactor kinetics with feedback reactivity and the reactor core thermal-hydraulics. Two channels are considered: the average and the hot channels to represent the reactor core. The developed computer program is compiled and executed on a personal computer using the FORTRAN language. The model is validated by safety-related benchmark calculation for MTR-Type reactors of IAEA 10 MW generic reactor for both slow and fast reactivity insertion transients. A good agreement is shown between the present model and the benchmark calculations. Then, the model is used for simulating uncontrolled withdrawal of a control plate of ETRR-2 for both transients: transient with over power scram trip and self-limited transient. The model results for ETRR-2 were analysed and discussed.

Economics, policy, supplies, forecasts

08/01970 A neural network based operation guidance system for procedure presentation and operation validation in nuclear power plants

Mo, K. *et al. Annals of Nuclear Energy*, 2007, 34, (10), 813–823.

An operation guidance system (OGS) was developed to regulate and supervise operators’ actions during abnormal environments in nuclear power plants. The system integrated a primitive computerized procedures system and an operation validation system (OVS) imbedded in a virtual simulated operational environment. As the key component of the OGS, OVS provided two important functions for the operators: validated check of operations, and qualitative and quantitative effects analysis of operations. Each of operators’ action was evaluated by the system and possible results were simulated by using artificial neural networks. Finally, corresponding suggestion or warning was provided to operators. This should reduce human errors during operation in emergency scenarios.

08/01971 A neutronic investigation on a helium cooled hybrid reactor using nitride fuels containing reactor grade plutonium

Übeyli, M. *et al. Applied Energy*, 2008, 85, (9), 855–866.

There has been a significant amount of reactor grade (RG) plutonium accumulated from the conventional nuclear reactors’ spent fuel. Destruction or reducing this RG plutonium is very important to prevent its misuse and/or release accidentally into the environment. Using very energetic fusion neutrons in fusion–fission (hybrid) reactors can burn the RG plutonium effectively. This study presents the burning of the mixed fuel containing RG plutonium and uranium in a helium-cooled hybrid reactor for an operation period of 24 months. The effect of various fuel mixtures and tritium breeders on the neutronic performance of the reactor as well as the burning of the RG plutonium was investigated. Calculations were carried out on an experimental hybrid blanket with the aid of SCALE4.3 by solving the Boltzmann transport equation with the XSDRNPM code. Numerical results showed that increasing RG plutonium content in the fuel increased the burning of plutonium and fusion energy multiplication substantially. The tritium breeder having the lowest lithium atomic density allowed the highest fission of the fuel in the blanket.

08/01972 A vision for a collaborative control room for ITER

Schissel, D. P. *Fusion Engineering and Design*, 2008, 83, (2–3), 539–544.

A vision for an onsite control room for ITER that will support worldwide experimental collaboration and operation is presented. Fusion experiments place a particular premium on near real time interactions with data and among members of the team. Enabling effective international collaboration on this scale is technically demanding, requiring powerful interactive tools and provision of a working environment for offsite personnel engaged in experimental operation that is every bit as productive as what is onsite. Expanding the view of the control room to include worldwide real time resources, both computational, data, and human, allows for a collaborative design that will significantly benefit ITER’s scientific productivity. While the worldwide fusion program has a significant track record for developing and exploiting remote collaborations, the community should recognize that the collaborative needs of other communities share some similarity and therefore joint or shared research into collaborative technologies will increase the benefit to all concerned.

08/01973 Design and construction of vacuum control system on EAST

Wang, L. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 295–299.

The construction of experimental advanced superconducting tokamak (EAST) was finished at the end of 2006 in Hefei, China. Its vacuum system, an important subsystem, has been commissioned in February 2006. The design and construction of this vacuum control system are described in this paper. The requirements for remote automation, distributed control and centralized management, high reliability and expansibility have been taken into account in the design. There are three levels of control in vacuum control system. The bottom level control is performed on the local instruments manually; the medium level control is based on Siemens S7–400 PLC; the top level control is conducted on IPCs with communication through profi_bus network. In addition remote handling and centralized monitoring could be realized by a remote control server. The control system could achieve pumping and fueling of the whole vacuum system. Besides that, it also includes the data acquisition of the pressure and temperature. The details are discussed on the monitoring of vacuum system states including cooling water, power and compressed air, etc., safeguards of plasma chamber and cryostat chamber and vacuum equipments, choosing of control modes corresponding to the plasma discharge and wall conditioning. At the end, the parts of EAST device protection system related to vacuum and gas injection system will also be introduced.

08/01974 Development of CAP process for fabrication of ThO_2–UO_2 fuels part II: characterization and property evaluation

Kutty, T. R. G. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 309–318.

Coated agglomerate pelletization (CAP) process is being developed for the fabrication of ThO_2–UO_2 mixed oxide fuel pellets. The procedure for the fabrication of ThO_2–4%UO_2 and ThO_2–20%UO_2 pellets by this process has been described in detail in part I of this series of papers. The present part II deals with the characterization of the above pellets by optical microscopy, scanning electron microscopy (SEM) and electron probe microanalysis (EPMA). The microstructure of the ThO_2–4%UO_2 and ThO_2–20%UO_2 pellets showed a duplex grain structure. Thermal expansion and thermal conductivity were measured in the temperature range from room temperature to 1500 °C. It was found that the thermal conductivity decreased by the addition of UO_2 to ThO_2 at any temperature. Addition of 20%UO_2 to ThO_2 caused very large decrease in thermal conductivity. The thermal expansion of ThO_2–20%UO_2 pellet was different from that of ThO_2 and ThO_2–4%UO_2, e.g. it increased more rapidly with increasing temperature in the temperature range of 1000–1500 °C.

08/01975 Qualitative response of safety injection system for a large size break in the reactor coolant system cold leg

Tahir, M. *et al. Annals of Nuclear Energy*, 2007, 34, (11), 922–925.

Safety injection system, accumulator injection system and residual heat removal system of CHASNUPP-1 were simulated using the computer code APROS. The qualitative response of the simulated system was observed during injection and re-circulation phases after LOCA. During rapid depressurization of SRC system due to leakage, these systems started coolant injection in the SRC system as per plant requirement. Different thermal-hydraulic parameters of the respective systems are presented and discussed. Results obtained are in good agreement with the reported document of the reference power plant.

08/01976 Reengineering of energy management

Gheorghiu, I. D. and Carabulea, A. *International Journal of Nuclear Governance, Economy and Ecology*, 2008, 2, (1), 82–89.

This paper discusses models of operational management re-engineering applied for the efficient use of nuclear energy, and the development of long-term decisions in economics–engineering system approach (the pattern of decision models and applications concerning systems profitableness in terms of sustainable development).

08/01977 The role of nuclear energy in the post-Kyoto carbon mitigation strategies

Rafaj, P. and Kypreos, S. *International Journal of Nuclear Governance, Economy and Ecology*, 2008, 2, (1), 10–27.

Policy scenarios examined in this paper provide insights into the long-term role that nuclear power could play in abating CO_2 emissions. Impacts are quantified for a strict phase-out of nuclear generation capacities, and are contrasted with scenarios allowing for a nuclear technology breakthrough under a specific carbon-tax regime. The energy-related global CO_2 emissions are reduced by nearly 50% relative to the baseline in 2050 in the carbon-tax scenario, allowing for policies in favour of nuclear energy. On the contrary, the emission-reduction levels are less ambitious for the same carbon tax when a worldwide phasing-out of nuclear power is adopted. The substantial increase in contribution of nuclear energy projected for the carbon mitigation does not represent an acute threat from the uranium resources scarcity point of view for the time horizon of analyses. Nevertheless, the cost of nuclear fuel supplies and waste disposal might increase significantly without adjustments in the technology used.

06 ELECTRICAL POWER SUPPLY AND UTILIZATION

Scientific, technical

08/01978 A critical survey of agent-based wholesale electricity market models

Weidlich, A. and Veit, D. *Energy Economics*, 2008, 30, (4), 1728–1759.

The complexity of electricity markets calls for rich and flexible modelling techniques that help to understand market dynamics and to derive advice for the design of appropriate regulatory frameworks. Agent-based computational economics (ACE) is a fairly young research paradigm that offers methods for realistic electricity market modelling. A growing number of researchers have developed agent-based models for simulating electricity markets. The diversity of approaches makes it difficult to overview the field of ACE electricity research; this literature survey should guide the way through and describe the state-of-the-art of this research area. In a conclusive summary, shortcomings of existing approaches and open issues that should be addressed by ACE electricity researchers are critically discussed.

08/01979 An exact piecewise method for fault studies in interconnected networks

Kalantari, A. and Kouhsari, S. M. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (3), 216–225.

Ever-increasing size and complexity of electrical networks call for new computational tools to cope with serious challenges such as information handling and security, massive data processing, real-time analysis and control, etc. In particular, this paper tries to deal with these challenges in the field of fault studies. Actually, a piecewise or diakoptical solution procedure, corresponding to the decentralized nature of electrical networks, has been adopted using large change sensitivity (LCS) concept. It first modifies the prefault voltage profile across utilities and then modifies their nodal Z_{bus} in such a way to reflect the effect of the whole network in local studies performed by individual utilities, i.e. an accurate federative analysis. Mathematical details of the proposed method as well as a numerical example will be presented. Practically, it has been implemented in an existing software package and simulation results for a typical network using this software are available at the end. Generally speaking, it can be used for distributed simulation of large-scale electrical networks across computer networks with the least investment on computational resources.

08/01980 Control of four leg inverter for hybrid power system applications with unbalanced load

Vechiu, I. *et al. Energy Conversion and Management*, 2007, 48, (7), 2119–2128.

This paper proposes an improved control strategy for a three phase, four leg inverter used for the simultaneous supply of three phase and single phase AC loads in a transformerless hybrid power system application. First, the mathematical model of the inverter is obtained by using the average technique, which allows converter systems to be rapidly and accurately simulated. Then, two control strategies are described. The first one uses the conventional *dq0* frame rotating with the angular frequency ω ($\omega = 314$ rad/s) and PI (proportional integral) controllers to ensure voltage and current regulation. The second one is an improved control strategy based on the decomposition of the supply three phase voltage and current into instantaneous positive, negative and homopolar sequence components using phasor representation. These three sequences are controlled independently in their own reference frames as DC signals. The positive sequence is regulated by the PI controllers in a positive reference frame, which rotates counterclockwise, while the negative sequence is regulated by the PI controllers in a negative reference frame, which rotates clockwise at the same angular frequency. Since the proposed strategy uses phasor representation, the actually superposed phasors of the homopolar sequence are spatially displaced at 120°. Then, using a negative reference frame system, the obtained DC signals are regulated by the PI controllers. Simulation results show the validity of the innovative control strategy.

08/01981 Dynamic voltage stability assessment of power transmission systems using neural networks

Vakil-Baghmisheh, M.-T. and Razmi, H. *Energy Conversion and Management*, 2008, 49, (1), 1–7.

With increased loading and exploitation of power transmission systems, voltage stability has become a growing concern in electric power utilities. Static analysis methods, such as power flow based methods, have difficulty in evaluating voltage stability due to using simple models for the system components. On the other hand, dynamic modeling and evaluation of voltage stability are complex, expensive and time consuming. In this paper, a neural network (NN) approach is presented for this purpose. This NN can establish a mapping between the operating conditions and the dynamic voltage stability margin of each bus. This analysis gives an insight about the robustness of various buses and dynamic voltage security status of the power system. The method is examined on Iran's north–west transmission network, and a mean absolute estimation error of 2.3% and a response time less than 0.1 s are obtained. By comparing the results obtained through different methods, it is concluded that the NN approach provides a compromise between accuracy and speed of calculations. Hence, for operational purposes, for which having fast response is vital, using the NN approach is recommended. On the other hand, for the design and development of power systems, using dynamic simulation seems a better approach due to its higher accuracy.

08/01982 Hybrid genetic algorithm approach for selective harmonic control

Dahidah, M. S. A. *et al. Energy Conversion and Management*, 2008, 49, (2), 131–142.

The paper presents an optimal solution for a selective harmonic elimination pulse width modulated technique suitable for a high power inverter used in constant frequency utility applications. The main challenge of solving the associated non-linear equations, which are transcendental in nature and, therefore, have multiple solutions, is the convergence, and therefore, an initial point selected considerably close to the exact solution is required. The paper discusses an efficient hybrid real coded genetic algorithm that reduces significantly the computational burden, resulting in fast convergence. An objective function describing a measure of the effectiveness of eliminating selected orders of harmonics while controlling the fundamental, namely a weighted total harmonic distortion is derived, and a comparison of different operating points is reported. It is observed that the method was able to find the optimal solution for a modulation index that is higher than unity. The theoretical considerations reported in this paper are verified through simulation and experimentally on a low power laboratory prototype.

08/01983 Improving the voltage dip immunity of converter-connected distributed generation units

Renders, B. *et al. Renewable Energy*, 2008, 33, (5), 1011–1018.

Voltage dip immunity of converter-connected distributed generation units will become increasingly important. This paper focuses on the relation between the voltage-dip ride-through capability of converters and their current-control strategy. A comparison is made between a recently proposed control strategy with programmable damping resistance and the classical sinewave control algorithm. The first-mentioned control structure will prove to yield an improved voltage dip immunity. Experimental tests on a single-phase full-bridge bidirectional converter are carried out and validate the aforementioned postulations.

08/01984 Multicontingency voltage stability monitoring of a power system using an adaptive radial basis function network

Chakrabarti, S. and Jeyasurya, B. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 1–7.

This paper proposes a scheme for online voltage stability monitoring for multiple contingencies using an enhanced radial basis function network (RBFN). A single RBFN is used to estimate MW margins for different contingencies. A sequential learning strategy is used along with a regularization technique to design the RBFN and the weights in the output layer are determined by using linear optimization. The proposed network can be adapted with changing operating scenario of the power system. A network pruning strategy is used to limit the growth of the network size due to adaptive training. The proposed scheme is applied on the New England 39-bus power system and the IEEE 118-bus power system.

08/01985 Optimal placement of capacitors in distribution systems using an immune multi-objective algorithm

Huang, T.-S. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (3), 184–192.

This work proposes a two-stage immune algorithm that embeds the compromise programming to perform multi-objective optimal capacitor placement. A new problem formulation model that involves fuzzy sets to reflect the imprecise nature of objectives and incorporates multiple planning requirements is presented. The proposed approach finds a set of non-inferior (Pareto) solutions rather than any single aggregated optimal solution. Additionally, this developed approach eliminates the need for any user-defined weight factor to aggregate all objectives. Comparative studies are conducted on an actual system with encouraging results, demonstrating the effectiveness of the proposed approach.

08/01986 Power system small signal stability region with time delay

Jia, H. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 16–22.

With the rapid development of phase measurement unit and wide area measurement system (PMU/WAMS), power system coordinated stability control has been paid more and more attention. Since there is obvious time delay in WAMS measurement, it is important to properly evaluate the impact of time delays on power system stability analysis and controller design. In this paper, influence of time delay on power system small signal stability region is deeply investigated. Small signal stability of differential algebraic equation with time delay is first reviewed as the necessary theoretical background. Then an optimal-based algorithm is given to trace boundaries of the small signal stability region with considering the time delay. Finally, two simple systems are employed to do some verification studies. It is found that time delay has significant influence to the boundary of the small signal stability region, especially when the time lag is large. This paper is helpful to properly consider the effect of time delay in power system controller design and small signal stability studies.

08/01987 Power system static security assessment and evaluation using external system equivalents

Srivani, J. and Swarup, K. S. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (2), 83–92.

Static security assessment and analysis using external system (Ward network) equivalent is presented. Contingency analysis is performed on the reduced network obtained using extended Ward equivalent. The Ward equivalent provides reasonably good results for contingency studies involving active power flows. Distribution factors method is used to perform contingency analysis. Fast line flow contingency screening is implemented for both the original unreduced network and the reduced network. The real power performance index (PI_{MW}) that reflects the degree of severity of contingencies is calculated using the screening method and full AC load flow method. The effectiveness of the proposed method is demonstrated by performing contingency analysis on a standard six-bus system, IEEE 14-bus, IEEE 30-bus and IEEE 57-bus systems, respectively. The performances of the reduced network and the screening method are compared with the traditional Newton–Raphson method and the results are discussed. The external network equivalent approach to security analysis was found to be suitable for fast line flow contingency analysis.

08/01988 Simulations and experiments on a 12 kW direct driven PM synchronous generator for wind power

Eriksson, S. *et al. Renewable Energy*, 2008, 33, (4), 674–681.

A direct driven permanent magnet (PM) synchronous generator has been designed and constructed and results from the first experimental tests are presented. The generator has been designed using the finite element method and dynamic simulations have been performed to study the generator. The simulations are performed by using an electromagnetic model, which is described by a combined field and circuit equation model and is solved in a finite element environment. The stator winding of the generator consists of circular cables and the rotor has surface mounted, arched PMs. A complete experimental setup has been constructed consisting of a motor, a frequency converter, a gearbox and electrical loads. Oscilloscopes are used to measure the voltage and the current for each phase. Measurements have been performed for both full load and no load at rated speed. The harmonic content of the voltage is analysed and compared to results from simulations. Furthermore, the generated electric power has been calculated from knowing the voltage and current and is compared to the simulated power. The agreement between experimental results and results from simulations based on finite element calculations is very high, especially considering harmonics. Several sources of error are suggested that could cause the small differences between the simulated results and the measured data for the constructed generator.

08/01989 Technique for voltage stability assessment using newly developed line voltage stability index

Arya, L. D. *et al. Energy Conversion and Management*, 2008, 49, (2), 267–275.

This paper presents an efficient technique for voltage stability assessment using a newly developed line voltage stability index that becomes half at a collapse point. Power flow equations have been used to identify critical lines, which may be vulnerable during an increased loading condition. Further, based on the line voltage stability index, a reliable scheme is proposed for protection against voltage collapse. It has been shown that as loading increases, the impedance seen by an impedance relay equals the impedance of the line at the collapse point for the most critical line. This condition has been obtained using the derived line voltage stability index. Hence, the proposed index could be easily implemented in a distant relay, either numerical or electromagnetic. This type of arrangement can give an alarm/tripping signal, indicating that the system has entered into an insecure zone from the voltage collapse viewpoint. The developed concept has been implemented on the standard 25 bus and 57 bus IEEE test systems, and the results have been compared with another proximity indicator known as the minimum eigenvalue of the load flow Jacobian.

08/01990 Voltage regulated hybrid DC power source using supercapacitors as energy storage device

Ayad, M.Y. *et al. Energy Conversion and Management*, 2007, 48, (7), 2196–2202.

The management of embedded electrical energy needs a storage system with high dynamic performances in order to shave transient power peaks and to compensate for the intrinsic limitations of the main source. The use of supercapacitors for this storage system is quite suitable because of appropriate electrical characteristics (huge capacitance, weak series resistance, high specific energy, high specific power), direct storage (energy ready for use) and easy control by power electronic conversion. This paper deals with the conception and realization of a voltage regulated hybrid DC power source using supercapacitors as an auxiliary storage device. Here, the structure, control principle and results are presented associated with experimental validation. The interest will be focused on the management of transient power peaks.

Economics, policy, supplies, forecasts

08/01991 A portfolio risk analysis on electricity supply planning

Huang, Y.-H. and Wu, J.-H. *Energy Policy*, 2008, 36, (2), 627–641.

Conventional electricity planning selects from a range of alternative technologies based on the least-cost method without assessing cost-related risks. The current approach to determining energy generation portfolios creates a preference for fossil fuel. Consequently, this preference results in increased exposure to recent fluctuations in fossil fuel prices, particularly for countries heavily depend on imported energy. This paper applies portfolio theory in conventional electricity planning with Taiwan as a case study. The model objective is to minimize the ‘risk-weighted present value of total generation cost’. Both the present value of generating cost and risk (variance of the generating cost) are considered. Risk of generating cost is introduced for volatile fuel prices and uncertainty of technological change and capital cost reduction. The impact of risk levels on the portfolio of power generation technologies is also examined to provide some valuable policy suggestions. Study results indicate that replacing fossil fuel with renewable energy helps reduce generating cost risk. However, due to limited renewable development potential in Taiwan, there is an upper bound of 15% on the maximum share of renewable energy in the generating portfolio. In the meantime, re-evaluating the current nuclear energy policy for reduced exposure to fossil fuel price fluctuations is worthwhile.

08/01992 An OPF based approach for assessing the minimal reactive power support for generators in deregulated power systems

Wu, H. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 23–30.

Reactive power support is an important ancillary service for secure and reliable operation in power markets. It has recently been recognized that the reactive power support for a generator has two components: one for supporting its own real power transmission and the other for supplying reactive demand, improving system security, and controlling system voltage; and that only the second part should receive financial compensation in competitive power markets. This makes the problem of separating these two components a new focus of current research. An OPF-based reactive power optimization model along with a power flow tracing based method is proposed in this paper to tackle this problem. The methodology is tested on four test systems. Detailed analysis of the results of the 39-bus test system is reported.

08/01993 Bulk power risk analysis: ranking infrastructure elements according to their risk significance

Koonce, A. M. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (3), 169–183.

Disruptions in the bulk power grid can result in very diverse consequences that include economic, social, physical, and psychological impacts. In addition, power outages do not affect all end-users of the system in the same manner. For these reasons, a risk analysis of bulk power systems requires more than determining the likelihood and magnitude of power outages; it must also include the diverse impacts power outages have on the users of the system. The authors propose a methodology for performing a risk analysis on the bulk power system. A power flow simulation model is used to determine the likelihood and extent of power outages when components within the system fail to perform their designed function. The consequences associated with these failures are determined by looking at the type and number of customers affected. Stakeholder input is used to evaluate the relative importance of these consequences. The methodology culminates with a ranking of each system component by its risk significance to the stakeholders. The analysis is performed for failures of infrastructure elements due to both random causes and malevolent acts.

08/01994 Capacity commitment and price volatility in a competitive electricity market

Tishler, A. *et al. Energy Economics*, 2008, 30, (4), 1625–1647.

The long lead time required to add new capacity in the electricity generation industry means that daily demands are necessarily served by capacity already installed. However, in a competitive market, even if the installed capacity was designed to serve the projected demands, frequent surpluses and occasional full utilization inevitably lead to price volatility. This paper develops a two-stage model of the generation market in which capacity construction occurs in stage 1, before demand realization, and price determination occurs in stage 2, when the equilibrium price ensures that the realized demand does not exceed the installed capacity. It is shown that price volatility and price spikes are inevitable, and that while price capping can mitigate high and volatile prices, it causes unmet demands and reduction in system reliability. This paper accentuates the interdependence among generating capacity, price volatility and service reliability, a primary cause of concern in the debate on electricity market reform.

08/01995 Capric acid and stearic acid mixture impregnated with gypsum wallboard for low-temperature latent heat thermal energy storage

Sari, A. *et al. International Journal of Energy Research*, 2008, 32, (2), 154–160.

A novel form-stable phase change wallboard (PCW) was prepared for low-temperature latent heat thermal energy storage by incorporating eutectic mixture of capric acid and stearic acid and gypsum wallboard. Thermal properties of form-stable PCW were measured by DSC analysis. The form-stable PCW has good thermal reliability with respect to the changes in its thermal properties after accelerated thermal cycling. Thermal performance test indicated that the use of such a type of PCW can decrease indoor air temperature fluctuation due to absorption of heat by the eutectic phase change material.

08/01996 Common and unique factors influencing daily swap returns in the Nordic electricity market, 1997–2005

Frestad, D. *Energy Economics*, 2008, 30, (3), 1081–1097.

This paper demonstrates that electricity swap returns can be explained by a set of uncorrelated common and unique risk factors. Electricity swap returns differ from return data in other markets by a significant portion of overall risk being unaccounted for by common factors. It follows that hedging a given exposure with an exposure in another segment of the swap market could be fallible. Furthermore, the volatility function common to all swaps may have to be augmented by unique risk in applied pricing applications.

08/01997 Demand side management in South Africa at industrial residence water heating systems using in line water heating methodology

Rankin, R. and Rousseau, P. G. *Energy Conversion and Management*, 2008, 49, (1), 62–74.

The South African electrical utility, ESKOM, currently focuses its demand side management (DSM) initiatives on controlling electrical load between 18:00 and 20:00 each day, which is the utility’s peak demand period. Funding is provided to energy service companies (ESCos) to implement projects that can achieve load shifting out of this period. This paper describes how an improved in line water heating concept developed in previous studies was implemented into several real life industrial sanitary water heating systems to obtain the DSM load shift required by ESKOM. Measurements from a selection of these plants are provided to illustrate the significant load reductions that are being achieved during 18:00–20:00. The measured results also show that the peak load reduction is achieved without adversely affecting the availability of sufficient hot water to the persons using the showering and washing facilities served by the water heating system. A very good correlation also exists between these measured results and simulations that were done beforehand to predict the DSM potential of the project. The in line water heater concept provides an improved solution for DSM at sanitary water heating systems due to the stratified manner in which hot water is supplied to the tanks. This provides an improved hot water supply to users when compared to conventional in tank heating systems, even with load shifting being done. It also improves the storage efficiency of a plant, thereby allowing the available storage capacity of a plant to be utilized to its full extent for load shifting purposes.

08/01998 Electricity consumption – real GDP causality nexus: evidence from a bootstrapped causality test for 30 OECD countries

Narayan, P. K. and Prasad, A. *Energy Policy*, 2008, 36, (2), 910–918.
This paper examines any causal effects between electricity consumption and real GDP for 30 Organization for Economic Co-operation and Development (OECD) countries. The authors use a bootstrapped causality testing approach and unravel evidence in favour of electricity consumption causing real GDP in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK. The implication is that electricity conservation policies will negatively impact real GDP in these countries. However, for the rest of the 22 countries the findings suggest that electricity conversation policies will not affect real GDP.

08/01999 Electricity prices and cross-border trade: volume and strategy effects

Parisio, L. and Bosco, B. *Energy Economics*, 2008, 30, (4), 1760–1775.
In this paper, the authors derive equilibrium bid functions in isolated domestic electricity markets and then analyse their modifications when cross-border trade among them is managed using the implicit auction method. It is shown that cross-border trade can induce price convergence across countries and thereby reallocate gains and losses as a result of two concomitant effects: a 'volume' effect due to the mere increase/decrease of demand and supply in each market and a 'bid effect' due to the modifications of bid functions brought about by interconnection. The latter effect can either contrast or reinforce the former. The authors derive conditions affecting the net result.

08/02000 Electricity wholesale market prices in Europe: convergence?

Zachmann, G. *Energy Economics*, 2008, 30, (4), 1659–1671.
This paper tests the hypothesis that the ongoing restructuring process in the European electricity sector has led to a common European market for electricity. Based on a principal component analysis of wholesale electricity prices in 2002–2006, the assumption of full market integration is rejected. For several pairs of countries, the weaker hypothesis of (bilateral) convergence is accepted based on unit root tests (KPSS and ADF) and a convergence test based on filtered pairwise price relations. This indicates that the efforts to develop a single European market for electricity were so far only partially successful. It is shown that the daily auction prices of scarce cross-border transmission capacities are insufficient to explain the persistence of international price differentials. Empirically, the findings confirm the insufficiency of explicit capacity auctions as stated in the theoretical literature.

08/02001 Emergency management in the Swedish electricity market: the need to challenge the responsibility gap

Palm, J. *Energy Policy*, 2008, 36, (2), 843–849.
A secure energy supply is a basic need of society. Along with electricity market deregulation, a responsibility gap has arisen, where private energy companies lack economic incentives to invest in an electricity distribution grid that is secured to the level desired by society. This article discusses the emergency management strategies of municipal authorities for securing the electricity supply, according to a networked, or 'governance', control and direction structure, and how this influences the relationship between electricity companies and Swedish municipalities. The Swedish electricity system has traditionally developed in a monopoly context. Since electricity market deregulation, the responsibility for electricity supply security has become unclear; field studies of Swedish municipalities indicate that all actors still seem to be seeking to find their proper roles in the deregulated market. Municipalities still expect to exercise influence over private energy company decisions regarding prioritization of emergency power deliveries. Energy companies vacillate between emphasizing their need to regard economic factors and their sense of responsibility for providing a secure electricity supply to vital municipal functions (even though municipalities may lack contracts specifying this).

08/02002 Energy efficiency and economic feasibility analysis of cogeneration system driven by gas engine

Sun, Z.-G. *Energy and Buildings*, 2008, 40, (2), 126–130.
A cogeneration system driven by gas engine is proposed and studied. The cogeneration system can provide electricity generation and cooling/heating for buildings. The cogeneration system has a large potential for energy saving and economical benefits. Primary energy rate and comparative primary energy saving are used to evaluate and compare the performances of the cogeneration system and conventional separate system. The comparative primary energy saving of the cogeneration system is more than 37% compared to conventional separate system at the required energy flows. The total annual income, the total annual saving and payback period of the cogeneration system are used to analyse its economy. The calculation result of economic analysis shows that the cogeneration system has a good economic benefits.

08/02003 Entry into the electricity market: uncertainty, competition, and mothballing options

Takashima, R. *et al. Energy Economics*, 2008, 30, (4), 1809–1830.
The present paper analyses the entry strategies into the electricity market of two firms that have power plants under price uncertainty and competition. The symmetric and asymmetric two firms are considered, which have either a thermal power plant or a nuclear power plant. The differences between the thermal power plant and the nuclear power plant, such as the cost structure and operational flexibility are modelled. The threshold values of market entry are calculated for each firm with either the thermal power plant or the nuclear power plant as the leader or the follower. The authors show the dependence of cost structures on entry thresholds of the leader and the follower into the electricity market. For various market and cost conditions, the diagrams of the leader are also shown.

08/02004 Evaluation of faults impacts on energy consumption and indoor air quality on an air handling unit

Ginestet, S. *et al. Energy and Buildings*, 2008, 40, (1), 51–57.
The effects of faults on an air handling unit (AHU) are often poorly evaluated [assuming indoor air quality (IAQ) problems], and underestimated in consumption balances. Based on an experimental site, this paper presents a quantitative study of some different faults that can appear on AHUs. Through a systemic analysis and a suitable modelling, the effects of several faults are simulated, using graphical software. Three families of faults are studied: control of a three-way valve, mixing box dampers (flow problems), and sensor inversion. Most of them find expression in an increase of the system consumption. The IAQ, seen here as the CO_2 rate, is studied thanks to the developed piece of software; the IAQ impact of faults is not accessible without such tool. The software is then applied to a combination of several faults, in order to bring out major tendencies.

08/02005 Exergoeconomic estimates for a novel zero-emission process generating hydrogen and electric power

Tsatsaronis, G. *et al. Energy*, 2008, 33, (2), 321–330.
This paper presents the exergoeconomic analysis of a novel process generating electric energy and hydrogen. Coal and high-temperature heat are used as input energy to the process. The process is a true 'zero-emission process' because (a) no NO_X is formed during coal combustion with sulfuric acid, and (b) the combustion products CO_2 and SO_2 are removed separately as compressed liquids from the overall process. The process cycle is based on two chemical reactions. The first reaction takes place in an electrolytic cell and delivers the hydrogen product. In the second step, coal reacts with sulfuric acid in a high-pressure combustion reactor. The combustion gas is expanded in a gas turbine to produce electric power. The combustion products are compressed and separated so that almost pure CO_2 can be removed from the cycle. The overall process is characterized by very high energetic and exergetic efficiencies. However, the overall process is very capital intensive. The electrolytic cell dominates the costs associated with the overall process. Detailed results of the thermodynamic simulation, the economic and the exergoeconomic analyses of the process including estimates of the product costs are presented.

08/02006 Fast Lagrangian relaxation for constrained generation scheduling in a centralized electricity market

Ongsakul, W. and Petcharaks, N. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 46–59.
This paper proposes a fast Lagrangian relaxation (FLR) for constrained generation scheduling (CGS) problem in a centralized electricity market. FLR minimizes the consumer payment rather than the total supply cost subject to the power balance, spinning reserve, transmission line, and generator operating constraints. FLR algorithm is improved by new initialization of Lagrangian multipliers and adaptive adjustment of Lagrangian multipliers. The adaptive subgradient method using high quality initial feasible multipliers requires much less number of iterations to converge, leading to a faster computational time. If congestion exists, the alleviating congestion index is proposed for congestion management. Finally, the unit decommitment is performed to prevent excessive spinning reserve. The FLR for CGS is tested on the 4 unit and the IEEE 24 bus reliability test systems. The proposed uniform electricity price results in a lower consumer payment than system marginal price based on uniformly fixed cost amortized allocation, non-uniform price, and electricity price incorporating side payment, leading to a lower

electricity price. In addition, observations on objective functions, pricing scheme comparison and interpretation of Lagrangian multipliers are provided.

08/02007 Fuel mix diversification incentives in liberalized electricity markets: a mean–variance portfolio theory approach

Roques, F. A. *et al. Energy Economics*, 2008, 30, (4), 1831–1849.

Monte Carlo simulations of gas, coal and nuclear plant investment returns are used as inputs of a Mean–Variance Portfolio optimization to identify optimal base load generation portfolios for large electricity generators in liberalized electricity markets. The authors study the impact of fuel, electricity, and CO_2 price risks and their degree of correlation on optimal plant portfolios. High degrees of correlation between gas and electricity prices – as observed in most European markets – reduce gas plant risks and make portfolios dominated by gas plant more attractive. Long-term power purchase contracts and/or a lower cost of capital can rebalance optimal portfolios towards more diversified portfolios with larger shares of nuclear and coal plants.

08/02008 Harmonization of renewable electricity feed-in laws: a comment

Söderholm, P. *et al. Energy Policy*, 2008, 36, (3), 946–953.

This comment aims at critically analysing some of the economic efficiency issues that are raised in an earlier study on the harmonization of feed-in law schemes for renewable electricity in the European Union. The authors consider the choice between green certificate systems and feed-in laws, but pay particular attention to the implementation and design of a harmonized feed-in law scheme. The authors argue first that the approach suggested in the earlier study tends to downplay many of the practical difficulties in assessing the real costs facing investors in renewable electricity, not the least since the presence of regulatory uncertainty about the marginal costs of renewable electricity may be essential for the choice between different support systems. Concerning the benefit side of renewable electricity promotion, the earlier paper builds on an interpretation of the EU Renewables Directive that provides plenty of room for national priorities and that therefore essentially implies that harmonized support premiums per se are of little value. The authors argue instead that a harmonized system should primarily address the international spillover effects from renewable electricity promotion, not the least those related to improved security of supply in Europe. There exists then a strong case for disregarding the specific national benefits of renewable electricity production in the design of harmonized support systems, and for instead considering international – perhaps at the start bilateral – policy support coordination based on entirely uniform support levels.

08/02009 Initial evaluation of the impact of post-combustion capture of carbon dioxide on supercritical pulverised coal power plant part load performance

Chalmers, H. and Gibbins, J. *Fuel*, 2007, 86, (14), 2109–2123.

Pulverized coal-fired plants often play an important role in electricity grids as mid-merit plants that can operate flexibly in response to changes in supply and demand. As a consequence, these plants are required to operate over a wide output range. This paper presents an initial evaluation of some potential impacts of adding post-combustion CO_2 capture on the part load performance of pulverized coal-fired plants. Preliminary results for ideal cases analysed using a simple high-level model indicate that post-combustion CO_2 capture could increase the options available to power plant operators. In particular, solvent storage could allow higher effective plant load factors to be achieved to assist with capital recovery while still permitting flexible operation for grid support. A number of areas for more detailed analysis are identified.

08/02010 Integration of wind-generating units into the Corsican electrical grid: determination of the maximal integration rate from a reliability analysis based on a stochastic process

Poggi, P. *et al. International Journal of Nuclear Governance, Economy and Ecology*, 2008, 2, (1), 63–81.

This paper investigates the potentiality of wind electric conversion systems (WECS) integrated into the islander electrical grid of Corsica. Probabilistic models for WECS and their use in the reliability studies of combined wind electric and conventional generation systems are discussed. The method, based on the evaluation of the loss of load probability (LOLP), uses a Markov model applied to the output power of 'classical' units and WECS, and to the hourly electrical energy demand. Then the margin state (the difference between grid total capacity state and load state) and its associated probability are computed to allow determination of the LOLP. So, the limit of the WECS power that can be supported by the grid is estimated. This study has been realized for the total thermal capacity installed in the grid and various ranges of WECS. Furthermore, the authors study the energetic balance on the grid with this wind farm and the benefit regarding gas emissions induced by this system.

08/02011 Internalizing externalities into capacity expansion planning: the case of electricity in Vietnam

Nguyen, K. Q. *Energy*, 2008, 33, (5), 740–746.

This paper examines the impacts of including external costs such as environmental and health damages from power production on power generation expansion planning in Vietnam. Using the MARKAL model and covering a 20-year period to 2025, the study shows that there are substantial changes in the generation structure in favour of renewable energy technologies and other low emitting technologies. These changes lead to a reduction in fossil fuel requirements, and consequently, a reduction of CO_2, NO_x, SO_2, and PM emissions which could be expected to also reduce the associated environmental and human health impacts. The avoided external costs would be equivalent to 4.4 US cent/kWh. However, these gains are not free as the additional electricity production cost would be around 2.6 US cent/kWh higher if the switch to more expensive, but lower emitting technologies were made. The net benefit of internalizing these externalities is thus around 1.8 US cent/kWh.

08/02012 Investments in liberalised power markets. Gas turbine investment opportunities in the Nordic power system

Jensen, S. G. and Meibom, P. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (2), 113–124.

There is considerable uncertainty in the Nordic electricity system with respect to long-term development in production capacity. The process towards liberalization of the electricity sector started with a situation of a large capacity margin, which is gradually vanishing. Since potential investors in new production capacity are unaccustomed with investments under the new regime, it is unknown if and when investments will take place. The purpose of this paper is to analyse if and when investors choose to invest in new production capacity depending on their existing portfolio of power producing units. Electricity price scenarios generated with a partial equilibrium model of the Nordic power system are combined with a model of investment decisions. In this, various scenarios for the development in key parameters such as CO_2 emission permit price and development in installed wind power capacity are used to investigate the consequences for investments in a natural gas fired power plant. The main result of the analysis is that new investments are highly sensitive to investors existing power production portfolio, as new production units compete with the existing power plants.

08/02013 Load duration curve: a tool for technico-economic analysis of energy solutions

Poulin, A. *et al. Energy and Buildings*, 2008, 40, (1), 29–35.

Accuracy and relevance of energy solution analysis for a customer could be greatly improved when considering the relationship between the electric power demand and time, information that is usually not readily available. In an attempt to fill this gap, the concept of customer load duration curve (LDC) has been investigated. A six parameters relationship has proven to be able to accurately represent measured annual and monthly LDC of 332 commercial, institutional and industrial customers. Plotted against the load factor, the values of each of the six parameters are shown to be constrained within specific ranges. This characteristic has lead to the development of an algorithm for the generation of realistic synthetic LDC. This kind of algorithm can be implemented in a technico-economic model for population studies or risk management through Monte Carlo simulations. Here, some results are presented for the assessment of a peak shaving application in commercial and industrial markets using Monte Carlo simulations.

08/02014 Marine-current power generation by diffuser-augmented floating hydro-turbines

Ponta, F. L. and Jacovkis, P. M. *Renewable Energy*, 2008, 33, (4), 665–673.

The oceans represent a huge energy reservoir consistent of stored solar and gravitational energy in several forms, causing ceaseless movements of an enormous volume of water. This energy is generally diffuse but, in many cases, significantly more concentrated than other forms of renewable energy already being successfully exploited on land. Among the ocean-energy resources, wave and marine-current energy emerge as the most promising options for massive ocean-energy generation in the immediate future. The main objective of this paper is to focus on trends that can lead to a feasible massive marine-current-power future scenario, and to introduce a technological solution which could help to reach that goal. The authors shall describe the main features of a floating marine-current-power system that introduces conceptual innovations in order to improve the technical and economical performance.

08/02015 Modeling of electricity consumption in the Asian gaming and tourism center – Macao SAR, People's Republic of China

Lai, T. M. *et al. Energy*, 2008, 33, (5), 679–688.

As the Macao Special Administrative Region becomes a gaming and tourism centre in Asia, modelling the consumption of electricity is critical to Macao's economic development. The purposes of this paper are to conduct an extensive literature review on modelling of electricity consumption, and to identify key climatic, demographic, economic and/or industrial factors that may affect the electricity consumption of a country/city. It was identified that the five factors, namely temperature, population, the number of tourists, hotel room occupancy and days per month, could be used to characterize Macao's monthly electricity consumption. Three selected approaches including multiple regression, artificial neural network (ANN) and wavelet ANN were used to derive mathematical models of the electricity consumption. The accuracy of these models was assessed by using the mean squared error, the mean squared percentage error and the mean absolute percentage error. The error analysis shows that wavelet ANN has a very promising forecasting capability and can reveal the periodicity of electricity consumption.

08/02016 Multicriteria evaluation of power plants impact on the living standard using the analytic hierarchy process

Chatzimouratidis, A. I. and Pilavachi, P. A. *Energy Policy*, 2008, 36, (3), 1074–1089.

The purpose of this study is to evaluate 10 types of power plants available at present including fossil fuel, nuclear as well as renewable-energy-based power plants, with regard to their overall impact on the living standard of local communities. Both positive and negative impacts of power plant operation are considered using the analytic hierarchy process. The current study covers the set of criteria weights considered typical for many local communities in many developed countries. The results presented here are illustrative only and user-defined weighting is required to make this study valuable for a specific group of users. A sensitivity analysis examines the most important weight variations, thus giving an overall view of the problem evaluation to every decision maker. Regardless of criteria weight variations, the five types of renewable energy power plant rank in the first five positions. Nuclear plants are in the sixth position when priority is given to quality of life and last when socioeconomic aspects are valued more important. Natural gas, oil and coal/lignite power plants rank between sixth and tenth position having slightly better ranking under priority to socioeconomic aspects.

08/02017 Novel approach to assess local market power considering transmission constraints

Li, C. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 39–45.

Market power (MP) assessment and mitigation affect the efficiency of the generation market. The traditional indices such as HHI and Lerner index can not express local market power, which caused by transmission constraints. Transmission constraints divide the market into some smaller parts. Some generators can abuse their MP in one part but not in the whole market. This paper describes a new approach to assess market power. The main contributions of the new method can be summarized as following. First, the concept of local market is developed, and the whole power system is divided into several local markets, as transmission congestions dividing the market. In the local markets, there are no transmission constraints so local market power does not exist. Then the local market power index (LMPI) is calculated according to market concentration, transmission constraints, and demand–supply ratio. Based on LMPI, the integrated LMPI, which describes the whole picture of market, can be obtained. It has been proved that the new approach can assess market power exactly, and identify the critical factor that results in market power and where generators are easy to exercise market power. The finding in this paper is helpful for market monitoring and mitigating market power. Moreover, the new index can be used to evaluate the power grid availability to generation competition and the power transmission expansion planning.

08/02018 Pattern recognition based digital relaying for advanced series compensated line

Samantaray, S. R. and Dash, P. K. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (2), 102–112.

This paper presents a new approach for fault analysis of advanced series compensated (thyristor controlled series compensated) line using pattern recognition approach. Here, *S*-transform (ST) is used to process the post fault current signal samples and features are extracted to identify the faulty phase and the faulty section involved in the fault process. The *S*-transform is an extension of wavelet transform, which possesses superior property over the latter as the moving functions are fixed with respect to time axis while the localizing scalable Gaussian window dilates and translates. Such a transform with moving and scalable localizing Gaussian window, therefore, provides excellent time localization property for different signals. Utilizing the ST, the time-frequency contours (ST coefficients) are generated for various fault conditions in advanced series compensated transmission system. Also an automatic fault recognition system is designed using probabilistic neural network (PNN) to provide the faulty phase and faulty section involved in the TCSC based line. The PNN is tested and trained with the features extracted from the ST contours for different fault situations. The proposed method is tested for all 11 types of shunt faults with wide range of operating conditions and provides accurate results.

08/02019 Peak and daily profile estimation for substations in rural networks

Tawalbeh, N. I. and Al-Fahed Nuseirat, A. M. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (3), 202–206.

The load of rural substations in north of Jordan is used to estimate the diversity and conversion factors. These factors are used to estimate the peak and daily load profile. The estimation is based on data collected by the SCADA system of Jordan Electric Power Co. (JEPCO). The results show that the conversion factor is independent of number of feeders, where the diversity factors are varies with number of feeders. The number of feeders variation on the diversity factors are just for a specified numbers. Estimated daily load profiles are compared to measured daily profiles.

08/02020 Prediction of the fuel impact associated with performance degradation in power plants

Verda, V. *Energy*, 2008, 33, (2), 213–223.

Diagnosis procedures are used in power plants in order to detect the presence of anomalies that affect the performance of a system and to locate the components where the anomalies have occurred. Any decision concerning maintenance strategies is conditioned by their economic convenience. The expected fuel saving that can be obtained by removing the anomalies represents an important information for such a decision. This evaluation, called prognosis, is not trivial when several anomalies occur in the plant, mainly because the anomalies change the operating conditions of all the components. In this paper, a prognosis procedure based on a productive representation of the system is proposed and applied to a system constituted by a gas turbine and a heat recovery system. Two anomalies are simulated in the turbine and in the heat recovery steam generator. The procedure allows one to predict the additional fuel consumption caused by each anomaly, with an error of less than 5%.

08/02021 Psychological determinants of attitude towards and willingness to pay for green electricity

Hansla, A. *et al. Energy Policy*, 2008, 36, (2), 768–774.

The results of a mail survey of 855 Swedish household consumers showed that willingness to pay for green electricity increased with a positive attitude towards green electricity and decreased with electricity costs. Attitude towards green electricity was in turn related to awareness of consequences of environmental problems for oneself, others, and the biosphere, concerns for these consequences, and self-transcedent value types.

08/02022 Reducing energy consumption by using self-organizing maps to create more personalized electricity use information

Räsänen, T. *et al. Applied Energy*, 2008, 85, (9), 830–840.

Identification of electricity use is one of the key elements to motivate customers to promote activities leading more efficient use of energy. Furthermore, electricity use comparisons with other similar customers give more interesting and concrete point of view to examine own consumption habits. In future, electricity providers and retailers are willing and probably forced by legislation to provide such information by the means of energy conservation and efficiency improvement. On the other hand, high number of customers set challenges to handle electricity use data and to create proper comparison information. In this study, an efficient and highly automated way to create comparison groups based on customers building characteristics is presented. The main advantages of the data-based approach are that customer location is noticed, comparison groups are created using concrete building information, data processing is highly automated and also method is computationally efficient. Additionally, presented method provide tool to target and to create customer specific electricity saving guidance. The performance of suggested approach was tested using data set which contained electricity use and building information concerning almost 8000 customers.

08/02023 Robust decentralised PI based LFC design for time delay power systems

Bevrani, H. and Hiyama, T. *Energy Conversion and Management*, 2008, 49, (2), 193–204.

In this paper, two robust decentralized proportional integral (PI) control designs are proposed for load frequency control (LFC) with communication delays. In both methodologies, the PI based LFC problem is reduced to a static output feedback control synthesis for a multiple delay system. The first one is based on the optimal H_∞ control design using a linear matrix inequalities technique. The second control design gives a suboptimal solution using a developed iterative linear matrix inequalities algorithm via the mixed H_2/H_∞ control technique. The control strategies are suitable for LFC applications that usually employ PI control. The proposed control strategies are applied to a three control area power system with time delays and load disturbance to demonstrate their robustness.

08/02024 Semi-transparent PV: thermal performance, power generation, daylight modelling and energy saving potential in a residential application

Wong, P. W. *et al. Renewable Energy*, 2008, 33, (5), 1024–1036.

In this research, semi-transparent PV is proposed as a top light material for residential applications. Using the results of field measurements, essential parameters pertaining to the power generation, thermal and optical characteristics of semi-transparent PV panels are understood. Calculation models presenting the above characteristics are developed and validated. The validated models are incorporated into energy plus to carry out overall energy consumption analyses in five climate regions in Japan to assess the energy saving potential of the semi-transparent PV panels. With appropriate optimization measures, the semi-transparent PV top light with 50% radiation transmission rate contributes to a maximum of 5.3% reduction in heating and cooling energy consumption compared with a standard BiPV roof. The effect of daylighting in lighting energy saving is subtle as most of the residential lighting demand occur during night-time. In the aspect of total energy consumption, net energy savings in the range of 3.0–8.7% are achieved for the 50% radiation transmission semi-transparent PV top light case relative to the base case of BiPV roof, where reduction in heating and cooling energy demand contributes most to the total energy saving.

08/02025 Simulation of off-grid generation options for remote villages in Cameroon

Nfah, E. M. *et al. Renewable Energy*, 2008, 33, (5), 1064–1012.

Off-grid generation options have been simulated for remote villages in Cameroon using a load of 110 kWh/day and 12 kWp. The energy costs of proposed options were simulated using HOMER, a typical village load profile, the solar resource of Garoua and the flow of river Mungo. For a 40% increase in the cost of imported power system components, the cost of energy was found to be 0.296 €/kWh for a micro-hydro hybrid system comprising a 14 kW micro-hydro generator, a 15 kW LPG generator and 36 kWh of battery storage. The cost of energy for photovoltaic (PV) hybrid systems made up of an 18 kWp PV generator, a 15 kW LPG generator and 72 kWh of battery storage was also found to be 0.576 €/kWh for remote petrol price of 1 €/l and LPG price of 0.70 €/m^3. The micro-hydro hybrid system proved to be the cheapest option for villages located in the southern parts of Cameroon with a flow rate of at least 200 l/s, while the PV hybrid system was the cheapest option for villages in the northern parts of Cameroon with an insolation level of at least 5.55 kWh/m^2/day. For a single-wire grid extension cost of 5000 €/km, operation and maintenance costs of 125 €/year/km and a local grid power price of 0.1 €/kWh, the breakeven grid extension distances were found to be 15.4 km for micro-hydro/LPG generator systems and 37.4 km for PV/LPG generator systems respectively. These results could be used in Cameroon's national energy action plan for the provision of energy services in the key sectors involved in the fight against poverty.

08/02026 Strategic bidding of generating units in competitive electricity market with considering their reliability

Soleymani, S. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (3), 193–201.

Restructured power systems are typically scheduled based on the offers and bids to buy and sell energy and ancillary services (AS) subject to operational and security constraints. Generally, no account is taken of unit reliability when scheduling it. Therefore generating units have no incentive to improve their reliability. This paper proposes a new method to obtain the equilibrium points for reliability and price bidding strategy of units when the unit reliability is considered in the scheduling problem. The proposed methodology employs the supply function equilibrium (SFE) for modelling a unit's bidding strategy. Units change their bidding strategies and improve their reliability until Nash equilibrium points are obtained. GAMS (general algebraic modelling system) language has been used to solve the market scheduling problem using DICOPT optimization software with mixed integer non-linear programming.

08/02027 The arguments for and against ownership unbundling of energy transmission networks

Pollitt, M. *Energy Policy*, 2008, 36, (2), 704–713.

The question this paper addresses is: what is the evidence for the superiority of the ownership unbundled transmission models (i.e. UK or Nord Pool hybrid) over other models? The authors assess the theoretical costs and benefits of ownership unbundling and judge these to be generally positive, though these may be potentially offset by the actual reorganization costs of the ownership unbundling process. Next, they assess the empirical evidence. This is in two forms: econometric evidence from samples of countries and case studies of reforms in particular jurisdictions. The econometric evidence is weak due to problems with simultaneity of reform steps and a lack of studies, but the case study evidence is compelling. The authors conclude with a discussion of the issues faced by countries considering implementing ownership unbundling. They also conclude that evidence seems to be that ownership unbundling of transmission is a key part of energy market reform in the most successful reform jurisdictions.

08/02028 The competitive role of the transmission system in price-regulated power industries

Arellano, M. S. and Serra, P. *Energy Economics*, 2008, 30, (4), 1568–1576.

This note shows how the transmission system can enhance competition in price-regulated power industries, thus extending earlier findings reported in the literature for deregulated industries. In the context of a two-technology, price-regulated power industry, it is shown that the interconnection of two markets initially supplied by a different monopoly reduces market power and raises welfare. The authors also show that the capacity of the transmission line plays a key role in determining whether market equilibrium lies closer to competition or monopoly.

08/02029 The electricity production capacity of photovoltaic power plants and the selection of solar energy sites in Andalusia (Spain)

Carrión, J. A. *et al. Renewable Energy*, 2008, 33, (4), 545–552.

The privileged climate and orographic setting of southern Spain give Andalusia an enormous potential for the installation of photovoltaic power plants connected to electricity grids and also for individual use. These circumstances as well as the present energy crisis, largely stemming from the world's dependence on fossil fuels, justify this research study. This article describes how the GIS was used to inventory the most suitable land sites for the location of solar power plants for the production of electrical energy in compliance with the legal, environmental, and operational requisites for grid-connected photovoltaic power plants (GPPPs). On the basis of this inventory and the calculation of the global irradiation on horizontal surface, it is estimated that the electrical production capacity of GPPPs in Andalusia doubles the special regime electricity demand. The resulting electricity production capacity is estimated at 38,693 GWh/year for 164,495.37 ha of land, which has no legal and/or environmental impediments to solar power installations.

08/02030 Transmission pricing in privately-owned electricity grids: an illustration from the Argentine electricity pool

Abdala, M. A. *et al. Energy Economics*, 2008, 30, (4), 1284–1305.

The Argentine electricity reform of 1992 offers an interesting example of decentralized transmission pricing arrangements within a competitive system. This paper is a shortened version of an original analysis made in 1994 of the regulation of the Argentine transmission system, with emphasis on investment cost allocation rules. To make up for the limitation of short-run marginal cost pricing, incentives on service quality were put in place, including penalties for lack of line availability. The mechanism for capacity expansion, based on *ad-hoc* rules for allocations of investment costs, had the potential to produce non-optimal investment outcomes, as such rules ignored beneficiaries on the demand side. For fine tuning of this system, an alternative rule was proposed based on traditional welfare analysis that broadens the universe of identified beneficiaries, and thus can be expected to produce a fairer outcome on investment cost allocation, reducing the potential risks of non-optimal investment. A brief postscript comments on the paper from the perspective of 2007.

08/02031 Using adaptive network based fuzzy inference system to forecast regional electricity loads

Ying, L.-C. and Pan, M.-C. *Energy Conversion and Management*, 2008, 49, (2), 205–211.

Since accurate regional load forecasting is very important for improvement of the management performance of the electric industry, various regional load forecasting methods have been developed. The purpose of this study is to apply the adaptive network based fuzzy inference system (ANFIS) model to forecast the regional electricity loads in Taiwan and demonstrate the forecasting performance of this model. Based on the mean absolute percentage errors and statistical results, it is possible to see that the ANFIS model has better forecasting performance than the regression model, artificial neural network model, support vector machines with genetic algorithms model, recurrent support vector machines with genetic algorithms model and hybrid ellipsoidal fuzzy systems for time series forecasting model. Thus, the ANFIS model is a promising alternative for forecasting regional electricity loads.

07 STEAM RAISING

Boiler operation/design

08/02032 Comparative assessment of sub-critical versus advanced super-critical oxyfuel fired PF boilers with CO_2 sequestration facilities

Rezvani, S. *et al. Fuel*, 2007, 86, (14), 2134–2143.

This work focuses on the techno-economic assessment of bituminous coal fired sub- and super-critical pulverized fuel boilers from an oxyfuel based CO_2 capture point of view. At the initial stage, two conventional power plants with a nominal power output of above 600 MWe based on the above steam cycles are designed, simulated and optimized. Built upon these technologies, CO_2 capture facilities are incorporated within the base plants resulting in a nominal power output of 500 MWe. In this manner, some sensible heat generated in the air separation unit and the CO_2 capture train can be redirected to the steam cycle resulting in a higher plant efficiency. The simulation results of conventional sub- and super-critical plants are compared with their CO_2 capture counterparts to disclose the effect of sequestration on the overall system performance attributes. This systematic approach allows the investigation of the effects of the CO_2 capture on both cycles. In the literature, super-critical plants are often considered for a CO_2 capture option. These, however, are not based on a systematic evaluation of these technologies and concentrate mainly on one or two key features. In this work several techno-economic plant attributes such as the fuel consumptions, the utility usages, the plant performance parameters as well as the specific CO_2 generation and capture rates are calculated and weighed against each other. Finally, an economic evaluation of the system is conducted along with sensitivity analyses in connection with some key features such as discounted cash flow rates, capital investments and plant efficiencies as well as fuel and operating costs.

08/02033 Designing capillary systems to enhance heat transfer in LS3 parabolic trough collectors for direct steam generation (DSG)

Rojas, M. E. *et al. Solar Energy*, 2008, 82, (1), 53–60.

Direct steam generation (DSG) has been the main research line in parabolic trough technology for many years now, due to its potential to improve the global efficiency of the power generation process. Based on the research performed, there is sufficient knowledge to design a pre-commercial power plant between 3 MWe and 5 MWe. In this design, the process parameters (flow rate, pressure and temperature) are being chosen to assure a reliable and flexible operation. The present point in time, with preparations being made for the actual construction of such a plant, seems an ideal moment for proposals in order to optimize the process for future plants. This paper proposes to incorporate capillary systems on the inner surface of the absorber pipes for DSG. A capillary system enhances the solar energy transfer to the internal fluid flow because, on one hand, it supports the wetting of the inner surface of absorbers under a stratified environment – due to capillary pumping – and, on the other hand, it promotes vaporization – nucleate boiling in the case of a porous medium or thin film evaporation in the case of a micro-channeled pipe. This paper presents a description of the required properties and characteristics of a capillary system (etched micro-channels or a porous coating) to be integrated in LS3 receivers in accordance with operating temperature limitations and the imposed solar heat flux.

08/02034 Exergy analysis of a 420 MW combined cycle power plant

Ameri, M. *et al. International Journal of Energy Research*, 2008, 32, (2), 175–183.

Combined cycle power plants (CCPPs) have an important role in power generation. The objective of this paper is to evaluate irreversibility of each part of Neka CCPP using the exergy analysis. The results show that the combustion chamber, gas turbine, duet burner and heat recovery steam generator (HRSG) are the main sources of irreversibility representing more than 83% of the overall exergy losses. The results show that the greatest exergy loss in the gas turbine occurs in the combustion chamber due to its high irreversibility. As the second major exergy loss is in HRSG, the optimization of HRSG has an important role in reducing the exergy loss of total combined cycle. In this case, LP-SH has the worst heat transfer process. The first law efficiency and the exergy efficiency of CCPP are calculated. Thermal and exergy efficiencies of Neka CCPP are 47 and 4.5.5% without duct burner, respectively. The results show that if the duct burner is added to HRSG, these efficiencies are reduced to 46 and 44%. Nevertheless, the results show that the CCPP output power increases by 7.38% when the duct burner is used.

08/02035 Influence of sodium deposits in steam generator tubes on remote field eddy current signals

Thirunavukkarasu, S. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (4), 211–218.

The presence of sodium deposits in defective regions of steam generator (SG) tubes of fast-breeder reactors is expected to influence the remote field eddy current signals. By exposing five SG tubes having uniform wall loss grooves to a sodium environment in a specially designed test vessel, changes in the shape of RFEC signals were observed and it was possible to approximate the volume of sodium deposited in defects. An invariant signal parameter was determined for quantitative characterization of defects despite the presence of sodium in the defects.

08/02036 Oxyfuel boiler design in a lignite-fired power plant

Kakaras, E. *et al. Fuel*, 2007, 86, (14), 2144–2150.

In the context of CO_2 capture and storage, the oxyfuel technology provides a promising option applicable in centralized power production schemes. This technology is based on combustion with pure oxygen instead of air and the flue gas mainly consists of CO_2 and H_2O. The work presented in this paper is focused in the application of the oxyfuel technology in a lignite-fired power plant. Significant design issues are the required extended flue gas recirculation in order to provide the ballasting effect of the absent N_2 and moderate the furnace temperatures. Therefore, a modified design of heat exchange surfaces of the oxyfuel steam boiler was formulated and was compared to a conventional air-fired boiler. A typical modern Greek air-fired power plant has been used as reference. The dominating factors that affect the dimensioning of the oxyfuel boiler are the higher radiative heat transfer – due to the high concentrations of CO_2 and H_2O in the flue gas – and the different flue gas mass flow, compared to a conventional air-fired boiler. For the determination of the thermodynamic cycle characteristics, simulations were made with the use of thermodynamic cycle calculation software.

08/02037 Rupture pressure of wear degraded alloy 600 steam generator tubings

Hwang, S. S. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 71–74.

Fretting/wear degradation at the tube support in the U-bend region of a steam generator (SG) of a pressurized water reactor has been reported. Simulated fretted flaws were machined on SG tubes of 195 mm in length. A pressure test was carried out with the tubes at room temperature by using a high pressure test facility which consisted of a water pressurizing pump, a test specimen section and a control unit. Water leak rates just after a ligament rupture or a burst were measured. Tubes degraded by up to 70% of the tube wall thickness (TW) showed a high safety margin in terms of the burst pressure during normal operating conditions. Tubes degraded by up to 50% of the TW did not show burst. Burst pressure depended on the defect depths rather than on the wrap angles. The tube with a wrap angle of 0° showed a fish-mouth fracture, whereas the tube with a 45° wrap angle showed a three-way fracture.

08 COMBUSTION

Burners, combustion systems

08/02038 Average structural analysis of the extractable material of young soot gathered in an ethylene inverse diffusion flame

Santamaría, A. *et al. Fuel*, 2007, 86, (12–13), 1908–1917.

Conventional analytical methods such as ^{1}H NMR, vapour pressure osmometry and elemental analysis were used to characterize the soot precursor material represented by the chloroform extractable fractions of the young soot gathered at different heights of an ethylene inverse diffusion flame in terms of average structural parameters. The results indicate that the soot soluble fraction obtained at a 6 mm height has a relatively large molecular weight and has long aliphatic chains which later disappear with an increase in height above the burner base, especially in the region where the temperature is high (1200 K). This behaviour is also accompanied by an increase in the aromaticity (f_a) of the samples.

08/02039 Catalytic effects of eight inorganic additives on pyrolysis of pine wood sawdust by microwave heating

Chen, M. Q. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 145–150.

In this paper, pyrolysis of pine wood sawdust was carried out by microwave heating at ca. 470 °C under dynamic nitrogen atmosphere. Eight inorganic additives [NaOH, Na_2CO_3, Na_2SiO_3, NaCl, TiO_2, HZSM-5, H_3PO_4, $Fe_2(SO_4)_3$] were investigated in terms of their catalytic effects on the pyrolysis. All of the eight additives have increased yields of solid products greatly and decreased yields of gaseous products more or less. Yields of liquid products have not subjected to dramatic change. The incondensable gases produced from pyrolysis consist mainly of H_2, CH_4, CO and CO_2. All of the eight additives have made these gases evolve earlier, among which the four sodium additives have the most marked effect. All the additives have made the amount of CH_4 and CO_2 decrease, while all of them except NaCl, TiO_2 and Fe_2 $(SO_4)_3$ have made that of H_2 increase and all of them except Na_2SiO_3 and HZSM-5 have made that of CO decrease. Alkaline sodium compounds NaOH, Na_2CO_3 and Na_2SiO_3 favor H_2 formation most. The most abundant organic component in the liquid products from pyrolysis of untreated sample and samples treated by all the additives except H_3PO_4 and $Fe_2(SO_4)_3$ is acetol. All the four sodium compounds favor acetol formation reaction and the selection increasing effect follows the order of $NaOH > Na_2CO_3 \approx Na_2SiO_3 > NaCl$. TiO_2 goes against the formation of acetol, HZSM-5 has no marked effect on acetol formation. The two dominant organic components identified in the liquid products from pyrolysis of H_3PO_4 and Fe_2 $(SO_4)_3$ treated samples are both fufural and 4-methyl-2-methoxy-phenol. A possible pathway for acetol formation is tentatively proposed.

08/02040 Closed vessel combustion of propylene–air mixtures in the presence of exhaust gas

Razus, R. *et al. Fuel*, 2007, 86, (12–13), 1865–1872.

The pressure–time evolution during the deflagration of gaseous propylene–air mixtures in the presence of their own exhaust gas was experimentally investigated in a spherical vessel, over an extended range of equivalence ratios, at room temperature and various initial pressures within 0.3–1.0 bar. The characteristic parameters of closed vessel explosions (peak pressure, maximum rate of pressure rise, time necessary to reach the peak pressure, explosion index) are examined in connection with the fuel/oxygen ratio and with exhaust gas concentration. The measured flammability parameters together with the computed values of adiabatic explosion pressures and adiabatic flame temperatures are used to examine the inerting effect of exhaust gas.

08/02041 Computational study of the combustion process and NO formation in a small-scale wood pellet furnace

Klason, T. and Bai, X. S. *Fuel*, 2007, 86, (10–11), 1465–1474.

This paper presents a computational study of the combustion process of wood pellets in a small-scale grate fired furnace. The objectives were to obtain detailed information on the combustion characteristics and NO formation in the furnace, and to examine the effect of secondary air on the combustion process. The simulation results were compared with experimental data in terms of flame temperature and distributions of species concentrations, including CO and NO. It was shown that the combustion process is strongly controlled by the inflow turbulence from the secondary and tertiary air jets. The combustion process is not sensitive to the bed combustion process in the present test case. The high speed air flow from the secondary and tertiary air inlets 'destroys' the history of the effluent volatile gases from the fuel bed. Different paths for the NO emission were investigated, including the thermal NO, the fuel-NO and NO from the N_2O intermediate mechanisms. The fuel-NO path is responsible for the rapid NO increase and the high NO peak near the fuel bed. Fuel-NO is rather low far downstream owing to the rather low nitrogen content in the fuel (less than 0.1% on mass basis), and the de-NO_x reactions with NH_3. NO is likely formed from the N_2O intermediate mechanism far downstream.

08/02042 Determination of kinetic parameters for Finnish milled peat using drop tube reactor and optical measurement techniques

Lehto, J. *Fuel*, 2007, 86, (12–13), 1656–1663.

The present paper deals with the pyrolysis of Finnish milled peat with different residence times in the laboratory-scale drop tube reactor. Based on the experimental results, the kinetic parameters for Finnish milled peat are determined and some important properties of the reactor and peat are identified using optical measurement techniques. Furthermore, it is demonstrated that in drop tube reactors the drag coefficient of the fuel particle might be a major source of error.

08/02043 Determination of trace lead in water samples by graphite furnace atomic absorption spectrometry after preconcentration with nanometer titanium dioxide immobilized on silica gel

Liu, R. and Liang, P. *Journal of Hazardous Materials*, 2008, 152, (1), 166–171.

Nanometer titanium dioxide immobilized on silica gel (immobilized nanometer TiO_2) was prepared by sol–gel method and characterized using X-ray diffraction (XRD) and scanning electron microscope (SEM). The adsorptive capability of immobilized nanometer TiO_2 for lead was assessed in this work using column method. It was found that lead can be quantitatively retained by immobilized nanometer TiO_2 in the pH range 4–7, then eluted completely with 1.0 mol L^{-1} HCl. The adsorption capacity of immobilized nanometer TiO_2 for Pb was found to be 3.16 mg g^{-1}. A new method has been developed for the determination of trace lead based on preconcentration with a microcolumn packed with immobilized nanometer TiO_2 prior to its determination by graphite furnace atomic absorption spectrometry (GFAAS). The detection limit of this method for Pb was 9.5 ng L^{-1} with an enrichment factor of 50, and the relative standard deviations (R.S.D.s) was 3.2% at the 10 ng mL^{-1} Pb level. The method was validated using a certified reference material, and was applied for the determination of trace lead in water samples.

08/02044 Flash pyrolysis of Silopi asphaltite in a free-fall reactor under vacuum

Sezer, M. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 89–95.

Flash pyrolysis experiments on asphaltite samples were performed in a free-fall reactor under vacuum to determine the effects of pyrolysis temperature, feed rate and particle size. Maximum liquid yield of 13 wt.% was obtained in free-fall reactor under vacuum when the pyrolysis temperature was 700 °C, feed rate was 0.4 g min^{-1} and particle sizes were between 0.075 and 0.250 mm. The liquid products obtained at various pyrolysis conditions were analysed by gas chromatography/ mass spectrometer and liquid products were classified as following: C5–C10, C11–C15, C16–C20 and C20+. The amount of saturated hydrocarbons decreased while the amount of unsaturated hydrocarbons increased with increase of temperature. While percent of C5–C10 unsaturated hydrocarbons continuously increased with increase of temperature, the percent of C11–C15 unsaturated hydrocarbons increased up to 750 °C and then started to diminish. Functional group analysis of solid residue was carried out using Fourier transform infrared spectrometry. The proximate analysis of solid residue indicated that percent of fixed carbon and ash increased with temperature.

08/02045 Flash-boiling atomization

Sher, E. *et al. Progress in Energy and Combustion Science*, 2008, 34, (4), 417–439.

Flash-boiling atomization is one of the most effective means of generating a fine and narrow-dispersed spray. Owing to its complexity its potential has not been fully realized to date. The paper reviews the present knowledge of the different mechanisms involved in the flash-boiling atomization process. These include intense nucleation, fast bubbles' growth and liquid atomization. The inter-relationships between the distinctive processes determine the spray quality. Recent experimental observations and physical interpretations have improved our insight and led to better understanding of the whole process. One practical result is the establishment of design criteria for an optimal flash-boiling atomizing system.

08/02046 Forced oscillation in diffusion flames near diffusive–thermal resonance

Wang, H. Y. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 630–639.

In this paper, a systematic analysis of forced oscillation was carried out in planar diffusion flames under weak external forcing. The external forcing is introduced by independently imposing a flow field with small amplitude fluctuations. Employing the asymptotic theory of Cheatham and Matalon, the linear response is first examined. It is shown that when the Damköhler number Da is close to the critical value Da^* corresponding to the marginal state of diffusive–thermal pulsating instability, the imposed velocity fluctuation may induce very large amplitude of flame oscillation as the frequency of velocity fluctuation c approaches c_0, the flame oscillation frequency at the onset of instability. This is a resonance phenomenon between the imposed flow oscillations and the intrinsic flame oscillations that are driven by the diffusive–thermal instability, and hence, this is referred to as the diffusive–thermal resonance. The non-linear near-resonant response is then examined with the Damköhler number *Da* chosen to be very close to the critical Damköhler number *Da**, and an evolution equation is derived for the amplitude of forced oscillation. Examination of the evolution equation reveals that in most situations, flames with larger Lewis number of fuel, smaller initial mixture strength, and smaller temperature difference between the oxidant and fuel stream are more responsive to the external forcing.

08/02047 Inverse estimation for temperatures of outer surface and geometry of inner surface of furnace with two layer walls

Chen, C.-K. and Su, C.-R. *Energy Conversion and Management*, 2008, 49, (2), 301–310.

This study provides an inverse analysis to estimate the boundary thermal behaviour of a furnace with two layer walls. The unknown temperature distribution of the outer surface and the geometry of the inner surface were estimated from the temperatures of a small number of measured points within the furnace wall. The present approach rearranged the matrix forms of the governing differential equations and then combined the reversed matrix method, the linear least squares error method and the concept of virtual area to determine the unknown boundary conditions of the furnace system. The dimensionless temperature data obtained from the direct problem were used to simulate the temperature measurements. The influence of temperature measurement errors upon the precision of the estimated results was also investigated. The advantage of this approach is that the unknown condition can be directly solved by only one calculation process without initially guessed temperatures, and the iteration process of the traditional method can be avoided in the analysis of the heat transfer. Therefore, the calculation in this work is more rapid and exact than the traditional method. The result showed that the estimation error of the geometry increased with increasing distance between measured points and inner surface and in preset error, and with decreasing number of measured points. However, the geometry of the furnace inner surface could be successfully estimated by only the temperatures of a small number of measured points within and near the outer surface under reasonable preset error.

08/02048 Low-temperature pyrolysis of wood waste containing urea–formaldehyde resin

Girods, P. *et al. Renewable Energy*, 2008, 33, (4), 648–654.

A study of the first phase of a thermal two-step process of valorization for waste containing urea–formaldehyde (UF resins) such as particle boards is presented. The first step of the process known as 'purification' is a low-temperature pyrolysis (250–300 °C) achieved for the selective desorption of the additives and their recovery. The second step is a reduction/gasification of the carbonaceous residue by thermochemical attack in CO_2 or in water vapour, to obtain CO/H_2 gases. First experiments have been carried out on a thermobalance to check the feasibility of the selective desorption of UF resin from wood. It appears that the temperature ranges linked to the degradation of wood are different from those obtained for the degradation of urea–formaldehyde resin. Thus, these results enable a selective pyrolysis. Particle board pyrolysis is also studied on an analysis device allowing a semi-continuous analysis by Fourier transform infrared (FTIR) spectrometry of pyrolysis products such as CO, CO_2, CH_4, NH_3 and HNCO. Elementary analysis and studies in calorimetric bomb enable the characterization of residues after treatment. It appears that the nitrogen quantity eliminated is not influenced by the treatment temperature: the quality of the process does not depend on the temperature of the treatment. However, an acceleration of the carbon is also observed, oxygen and hydrogen elimination, which implies a loss of energy. These results are validated by the study of residues in calorimetric bomb, which leads to an energy loss of approximately 10% for a treatment temperature between 250 and 300 °C.

08/02049 Microwave-assisted pyrolysis of CH_4/N_2 mixtures over activated carbon

Fidalgo, B. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 158–162.

The aim of this work was to study the microwave-assisted pyrolysis of CH_4 over an activated carbon, which acted as both microwave receptor and catalyst, and the influence of using different CH_4/N_2 ratios on the conversion of CH_4 to H_2. In order to compare the results obtained in the microwave oven, the pyrolysis was also carried out under conventional heating (electric furnace, EF). The effects of N_2, which enhanced significantly CH_4 conversion, differed depending on the heating device used. Under EF heating, N_2 seemed to have an effect similar to distribute the CH_4 molecules within the activated carbon bed. Under microwave heating (MW), the N_2, as well as distributing the CH_4 molecules, favoured the generation of energetic microplasmas, leading to higher conversions. The prevalence of one role over the other depended on the CH_4/N_2 ratio, the appearance of energetic microplasmas being favoured with high percentages of N_2. Consequently, CH_4 conversion was higher at low CH_4/N_2 ratios. Additionally, the formation of carbon nanofibres in experiments where a combination of N_2 and MW heating was used is also reported.

08/02050 MIKE 3 versus HARTMANN apparatus: comparison of measured minimum ignition energy (MIE)

Janes, A. *et al. Journal of Hazardous Materials*, 2008, 152, (1), 32–39.

In this study, MIE values measured with two different explosion tubes, HARTMANN and MIKE 3, are compared. Generally, MIKE 3 apparatus provides MIE results, which are equal or lower to those measured with the HARTMANN apparatus; this is particularly true for the energy ranges between 1 and 10 mJ and higher than 100 mJ. Differences observed can modify samples classification according to their sensitivity to electrostatic ignition sources. Nevertheless, ignition of a dust cloud by an electrostatic discharge is complex, and implies a different mechanism from that occurring during MIE tests. Thus, it seems difficult to synchronize dust dispersion and spark triggering to obtain optimal concentration in the spark area. Moreover, spark characteristics such as duration or energy feeding rate of spark cannot reproduce exactly industrial-world ones. On this point, it is not possible to conclude if characteristics of MIKE 3 electric circuit, e.g. resistance and inductance, are more relevant than HARTMANN circuit ones.

08/02051 Nitrogen chemistry in coal pyrolysis: catalytic roles of metal cations in secondary reactions of volatile nitrogen and char nitrogen

Tsubouchi, N. and Ohtsuka, Y. *Fuel Processing Technology*, 2008, 89, (4), 379–390.

The present review focuses on elucidating the chemistry of nitrogen release during coal pyrolysis, in particular, on making clear catalytic roles of inherent Ca and Fe ions in not only the partitioning of volatile-N to tar-N, HCN, NH_3 and N_2 but also the conversion of char-N to N_2. In slow heating rate pyrolysis of low-rank coals at 1000 °C with a fixed bed reactor, the demineralization with acid washing increases tar-N and HCN, but it decreases NH_3. On the other hand, the ion-exchange of Ca^{2+} ions with the demineralized coals shows the nearly reverse effect on the distribution of these nitrogen species, though the physical mixing of $Ca(OH)_2$ is almost ineffective. Since the sum of tar-N, HCN and NH_3 is unchanged significantly in any cases, it is likely that Ca cations, which exist originally in the ion-exchanged forms, can control the partitioning of volatile-N to tar-N, HCN, and NH_3. The Fe^{3+} ions precipitated on the demineralized coals catalyse the decomposition of tar-N, HCN and NH_3 into N_2. The evolution of N_2 from coal-N occurs even in the absence of any metal cations added. The extent is generally larger with a lower rank coal, at a slower heating rate and a higher temperature, and at a longer solid residence time when coal is rapidly pyrolysed. N_2 yield at 1350 °C reaches about 70% at maximum. Since a strong reverse correlation exists between N_2 and char-N, N_2 originates predominantly from char-N (and/or precursors). Demineralization of low-rank coals decreases N_2, whereas subsequently added Fe or Ca cations enhance N_2 mainly at $\leq$1000 °C or $\geq$1000 °C, respectively. As the sum of naturally present Fe and Ca cations increases, N_2 yield at 1350 °C tends to increase up to about 1 mass%. It can be proposed that fine particles of metallic Fe and CaO, which are formed from these inherent ion-exchanged cations, promote efficiently N_2 formation from char-N through solid–solid interactions with heterocyclic nitrogen forms in char matrix.

08/02052 Progression in sulfur isotopic compositions from coal to fly ash: examples from single-source combustion in Indiana

Jiang, Y. *et al. International Journal of Coal Geology*, 2008, 73, (3–4), 273–284.

Sulfur occurs in multiple mineral forms in coals, and its fate in coal combustion is still not well understood. The sulfur isotopic composition of coal from two coal mines in Indiana and fly ash from two power plants that use these coals were studied using geological and geochemical methods. The two coal beds are Middle Pennsylvanian in age; one seam is the low-sulfur (<1%) Danville Coal Member of the Dugger Formation and the other is the high-sulfur (>5%) Springfield Coal Member of the Petersburg Formation. Both seams have ash contents of approximately 11%. Fly-ash samples were collected at various points in the ash-collection system in the two plants. The results show notable difference in $\delta^{34}S$ for sulfur species within and between the low-sulfur and high-sulfur coal. The $\delta^{34}S$ values for all sulfur species are exclusively positive in the low-sulfur Danville coal, whereas the $\delta^{34}S$ values for sulfate, pyritic, and organic sulfur are both positive and negative in the high-sulfur Springfield coal. Each coal exhibits a distinct pattern of stratigraphic variation in sulfur isotopic composition. Overall, the $\delta^{34}S$ for sulfur species values increase up the section in the low-sulfur Danville coal, whereas they show a decrease up the vertical section in the high-sulfur Springfield coal. Based on the evolution of $\delta^{34}S$ for sulfur species, it is suggested that there was influence of seawater on peat swamp, with two marine incursions occurring during peat accumulation of the high-sulfur Springfield coal. Therefore, bacterial sulfate reduction played a key role in converting sulfate into hydrogen sulfide, sulfide minerals, and elemental sulfur. The differences in $\delta^{34}S$ between sulfate sulfur and pyritic sulfur is very small between individual benches of both coals, implying that some oxidation occurred during deposition or postdeposition. The $\delta^{34}S$ values for fly ash from the high-sulfur Springfield coal (averaging 9.7‰) are greatly enriched in ^{34}S relative to those in the parent coal (averaging 2.2‰). This indicates a fractionation of sulfur isotopes during high-sulfur coal combustion. By contrast, the $\delta^{34}S$ values for fly-ash samples from the low-sulfur Danville coal average 10.2‰, only slightly enriched in ^{34}S relative to those from the parent coal (average 7.5‰). The $\delta^{34}S$ values for bulk S determined directly from the fly-ash samples show close correspondence with the $\delta^{34}S$ values for SO_4^{-2} leached from the fly ash in the low-sulfur coal, suggesting that the transition from pyrite to sulfate occurred via high-temperature oxidation during coal combustion.

08/02053 Spray combustion simulation including soot and NO formation

Watanabe, H. *et al. Energy Conversion and Management*, 2007, 48, (7), 2077–2089.

A numerical simulation of turbulent spray combustion was performed to predict the combustion behaviour in a jet burner that generates a high speed, high temperature jet of exhaust gas. The conservation equations of mass, momentum and energy in the turbulent flow field were solved in conjunction with the k–ε turbulence model. The soot distribution in the combustor was calculated by solving a transport equation for the soot mass fraction using simple expressions for the soot formation and oxidation rates. A post-processing NO formation model was used to predict the concentration of thermal and prompt NO. Calculated results are compared with experimental data to demonstrate the validity of the numerical model. The effect of heat radiation from soot on the combustion characteristics was also examined. The calculated temperature without soot radiation was higher than that of the experimental data. However, in the case with heat radiation from the soot, the differences between the calculated and experimental results became small. This is because the soot greatly affects the radiative heat transfer in the jet burner. In addition, the calculated exhaust NO mole fraction with soot is in good agreement with the experimental one, although that without soot is almost 10 times larger than the experimental one. Moreover, to improve the combustion behaviour in the jet burner, a numerical simulation considering a baffle plate that causes recirculation flows was also performed. When a suitable baffle plate is applied to the combustor, the NO mole fraction in the exhaust gas decreased by about 40%.

08/02054 Study of the behaviour of a flame resulting from the combustion of pine needles in a cylindrical basket

Saádaoui, M. *et al. International Journal of Thermal Sciences*, 2008, 47, (4), 293–305.

This experimental and numerical study examines the behaviour of a flame resulting from the combustion of pine needles. The objective of this work is to evaluate the performances of two models of combustion, the validity of these being discussed by comparing the results with experimental measurements. An apparatus was designed to simulate and study in laboratory conditions the flame and the near-field plume stemming from the combustion of an isolated shrub. The burner was made of a cylindrical wire mesh basket filled with pine needles ignited at the lower circumference of the basket. particle image velocimetry (piv) and laser doppler anemometry (LDA) were used to characterize the velocity field in the proximity of the fuel and to identify the propagation of the flame. A set of time-dependent equations is obtained for each phase and the coupling between the gas phases is rendered through exchange terms of mass, momentum and energy. Turbulence is approached by using a k–ε statistical model constructed from the Favre averaging method. The chemical kinetics is assumed as infinitely fast compared with other characteristics of the flow. Two models of turbulent combustion are tested. The first is the EDC model, which considers an immediate reaction and the direct transformation of fuel into water and carbon dioxide. The second is the β-pdf model, which is based on an instantaneous thermodynamic equilibrium at any point. The solution is performed numerically by a finite-volume method. The numerical results obtained are presented and compared to experimental measurements.

08/02055 The N_2O–carbon reaction: the influence of CO and potassium on reactivity and populations of oxygen surface complexes

López, D. and Calo, J. *Fuel*, 2007, 86, (12–13), 1900–1907.

N_2O reduction on two different chars promoted with potassium was investigated using temperature programmed reaction, as well as isothermal reaction followed by temperature programmed desorption. It was found that potassium promotion significantly increased the N_2O reduction activity of the phenolic resin char, but not for the Wyodak coal char. Additional CO in the reactor feed gas had no discernible effect on the N_2O reduction rate of the phenolic resin char, but it did significantly increase the reactivity of the promoted, demineralized Wyodak coal char. The latter is attributed to residual mineral matter impurities in the coal that are not removed by the demineralization process used.

08/02056 The stability of turbulent hydrogen jet flames with carbon dioxide and propane addition

Wu, Y. *et al. Fuel*, 2007, 86, (12–13), 1840–1848.

In the study the lift-off, blow-out and blow-off stability limits of hydrogen/propane flames and hydrogen/carbon dioxide flames were tested in three different mixing arrangements. The first was to premix hydrogen with carbon dioxide or propane to form a jet flame. The second was to add the gas as an annular jet around the hydrogen flame. The third was to inject into the centre of the hydrogen flame. Propane and carbon dioxide have the same density but create very different chemical kinetic changes when added to hydrogen flames. The results showed that when premixed with hydrogen, propane is more effective in flame lift-off and blow-out. The analysis of kinetic mechanisms revealed that the propane is the dominating fuel in determining the burning rate of the hydrogen/propane while carbon dioxide mainly acted to dilute the hydrogen/CO_2 mixture. Comparing the three mixing arrangements, the experiments showed that hydrogen flame can be effectively lifted or blown out when gases were in annular flow around the hydrogen flame. The isothermal mixing process of the co-flow configuration was discussed.

08/02057 Volatile release and particle formation characteristics of injected pulverized coal in blast furnaces

Chen, W.-S. *et al. Energy Conversion and Management*, 2007, 48, (7), 2025–2033.

Volatiles release and particle formation for two kinds of pulverized coals (a high volatile bituminous coal and a low volatile bituminous coal) in a drop tube furnace are investigated to account for the reactions of pulverized coal injected in blast furnaces. Two different sizes of feed particles are considered; one is 100–200 mesh and the other is 200–325 mesh. By evaluating the *R*-factor, the devolatilization extent of the larger feed particles is found to be relatively poor. However, the swelling behaviour of individual or two agglomerated particles is pronounced, which is conducive to gasification of the chars in blast furnaces. In contrast, for the smaller feed particles, volatiles liberated from the coal particles can be improved in a significant way as a result of the amplified *R*-factor. This enhancement can facilitate the performance of gas phase combustion. Nevertheless, the residual char particles are characterized by agglomeration, implying that the reaction time of the char particles will be lengthened, thereby increasing the possibility of furnace instability. Double peak distributions in char particle size are observed in some cases. This possibly results from the interaction of the plastic state and the blowing effect at the particle surface. Considering the generation of tiny aerosols composed of soot particles and tar droplets, the results indicate that their production is highly sensitive to the volatile matter and elemental oxygen contained in the coal. Comparing the reactivity of the soot to that of the unburned char, the former is always lower than the latter. Consequently, the lower is the soot formation, the better is the blast furnace stability.

Fire safety

08/02058 Flame acceleration and transition to detonation in ducts

Ciccarelli, G. and Dorofeev, S. *Progress in Energy and Combustion Science*, 2008, 34, (4), 499–550.

This paper reviews the state of knowledge on flame acceleration and deflagration-to-detonation transition (DDT) in smooth ducts and ducts equipped with turbulence-producing obstacles. The objective is to bring to light the basic understanding of the phenomenon and its application to explosion safety. The scope of the review is restricted to homogeneous gas-phase combustion with emphasis placed on experimental investigation.

08/02059 Preparation and properties studies of halogen-free flame retardant form-stable phase change materials based on paraffin/high density polyethylene composites

Cai, Y. *et al. Applied Energy*, 2008, 85, (8), 765–775.

The halogen-free flame retardant form-stable phase change materials (PCM) based on paraffin/high density polyethylene (HDPE) composites were prepared by using twin-screw extruder technique. The structures and properties of the form-stable PCM composites based on intumescent flame retardant system with expandable graphite (EG) and different synergistic additives, such as ammonium polyphosphate (APP) and zinc borate were characterized by scanning electronic microscope, thermogravimetric analyses, dynamic Fourier-transform infrared spectra, differential scanning calorimeter (DSC) and cone calorimeter test. The TGA results showed that the halogen-free flame retardant form-stable PCM composites produced a larger amount of charred residue at 700°, although the onset of weight loss of the halogen-free flame retardant form-stable PCM composites occurred at a lower temperature due to the thermal decomposition of flame retardant. The DSC measurements indicated that the additives of flame retardant had little effect on the thermal energy storage property, and the temperatures of phase change peaks and the latent heat of the paraffin showed better occurrence during the freezing process. The dynamic FTIR monitoring results revealed that the breakdowns of main chains (HDPE and paraffin) and formations of various residues increased with increasing thermo-oxidation temperature. It was also found from the Cone calorimeter tests that the peak of heat release rate (PHRR) decreased significantly. Both the decrease of the PHRR and the structure of charred residue after combustion indicated that there was a synergistic effect between the EG and APP, contributing to the improved flammability of the halogen-free flame retardant form-stable PCM composites.

09 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

08/02060 A new version of CSFB, comprehensive simulator for fluidised bed equipment

de Souza-Santos, M. L. *Fuel*, 2007, 86, (12–13), 1684–1709.

A comprehensive simulation program for fluidized bed equipment (CSFB) has been improved and is now able to predict operational conditions of bubbling and circulating fluidized bed equipment such as boilers, gasifiers, dryers, shale-retorting reactors, and pyrolysers with various designs and consuming a wide range of feedstock. This paper concentrates on the improvements on the original bubbling model. Comparisons between simulation results and real equipment operational conditions under bubbling fluidized bed techniques are presented. Since those comparisons showed relatively low deviations, it is believed that CSFB is useful for improving operational conditions of existing industrial units and as auxiliary tool for designing of new equipment.

08/02061 Analysis and cost optimization of the triple-pressure steam-reheat gas-reheat gas-recuperated combined power cycle

Bassily, A.M. *International Journal of Energy Research*, 2008, 32, (2), 116–134.

In this paper, the triple-pressure steam-reheat gas-reheat recuperated combined cycle (the regular gas-reheat cycle) was optimized relative to its operating parameters, including the temperature differences for pinch points (δT_{PP}). The optimized triple-pressure steam-reheat gas-reheat recuperated combined cycle (the optimized cycle) had much lower δT_{PP} than that for the regular gas-reheat cycle so that the area of heat transfer of the heat recovery steam generator (HRSG) of the optimized cycle had to be increased to keep the same rate of heat transfer. For the same mass flow rate of air, the optimized cycle generates more power and consumes more fuel than the regular gas-reheat cycle. An objective function of the net additional revenue (the saving of the optimization process) was defined in terms of the revenue of the additional generated power and the costs of replacing the HRSG and the additional fuel. Constraints were set on many operating parameters such as the minimum temperature difference for pinch points (δT_{PPm}), the steam turbines inlet temperatures and pressures, and the dryness fraction at steam turbine outlet. The net additional revenue was optimized at 11 different maximum values of turbine inlet temperature using two different methods: the direct search and variable metric. The performance of the optimized cycle was compared with that for the regular gas-reheat cycle and the triple-pressure steam-reheat gas-reheat recuperated reduced-irreversibility combined cycle (the reduced-irreversibility cycle). The results indicate that the optimized cycle is 0.17–0.35 percentage point higher in efficiency and 5.3–6.8% higher in specific work than the reduced-irreversibility cycle, which is 2.84–2.91 percentage points higher in efficiency and 4.7% higher in specific work than the regular gas-reheat cycle when all cycles are compared at the same values of TIT and δT_{PPm}. Optimizing the net additional revenue could result in an annual saving of 33.7 million US dollars for a 481 MW power plant. The optimized cycle was 3.62 percentage points higher in efficiency than the most efficient commercially available H-system combined cycle when compared at the same value of TIT.

08/02062 Analysis of the impacts of combining carbon taxation and emission trading on different industry sectors

Lee, C. F. *et al. Energy Policy*, 2008, 36, (2), 722–729.

Application of price mechanisms has been the important instrument for carbon reduction, among which the carbon tax has been frequently advocated as a cost-effective economic tool. However, blanket taxes applied to all industries in a country might not always be fair or successful. It should therefore be implemented together with other economic tools, such as emission trading, for CO_2 reduction. This study aims to analyse the impacts of combining a carbon tax and emission trading on different industry sectors. Results indicate that the ‘grandfathering rule (RCE2000)’ is the more feasible approach in allocating the emission permit to each industry sector. Results also find that the accumulated GDP loss of the petrochemical industry by the carbon tax during the period 2011–2020 is 5.7%. However, the accumulated value of GDP will drop by only 4.7% if carbon taxation is implemented together with emission trading. Besides, among petrochemical-related industry sectors, up-stream sectors earn profit from emission trading, while down-stream sectors have to purchase additional emission permits due to failure to achieve their emission targets.

08/02063 Analytic solutions for the geometric and optical properties of stationary compound parabolic concentrators with fully illuminated inverted V receiver

Fraidenraich, N. *et al. Solar Energy*, 2008, 82, (2), 132–143.

Stationary low concentrator collectors ($C < 2$), of the compound parabolic concentrators (CPC) type, are of great interest because of their potential to supply thermal energy for industrial processes, at temperatures below or around 90 °C. In particular, concentrators with fully illuminated inverted V absorbers have attractive properties for thermal energy production. Two classes of CPCs with inverted V absorber are identified, according to the relationship between the vertex angle of the absorber (γ) and the acceptance angle of the cavity (θ_a), ($\gamma \geq \theta_a$) or ($\gamma < \theta_a$). The first class of CPCs ($\gamma < \theta_a$) converge to the fully illuminated CPC with horizontal flat receiver when ($\gamma = 90°$). The second class of CPCs ($\gamma < \theta_a$) converge to the fully illuminated CPC with vertical flat receiver when ($\gamma = 0°$). Both limiting cases have been published in the technical literature. This paper analyses the class of concentrators satisfying ($\gamma \geq \theta_a$). The ideal concentrator corresponding to a fully illuminated wedge absorber and ($\gamma \geq \theta_a$) is a circular involute plus three parabolic segments. Closed-form analytic solutions are derived for its geometric and optical properties: reflector geometry, aperture, height, reflector length, angular acceptance function and average number of reflections for any degree of truncation. The equations obtained can be used as important design tools, for simulation techniques and optimization purposes. The collectible energy for north–south and east–west oriented collectors, for various receiver vertex angle and acceptance angle, was calculated. A cost-benefit figure, given by the relationship between collectible energy and reflector surface, is also estimated. Numerical results for any degree of cavity truncation are presented. As the degree of truncation varies, a clear minimum of the length over aperture ratio (L/A) occurs. The geometric and optical characteristics of different low concentration CPCs (C, between 1 and 2, range of interest of stationary concentrators) show that the cavities with the minimal relationship between the length or height of the reflector surface and the aperture, (L/A) and (H/A), and the lower average number of reflections n correspond to the lowest angular acceptance concentrator (highest nominal concentration). If a concentration of 1.2 is desired, then the smallest ratios of (L/A), (H/A) and n, within the set of concentrators with maximal concentration (C) between 1 and 2, occur for ($C = 2$) (nominal acceptance half angle $\theta_a = 30°$). Collectible energy results together with a cost-benefit relationship enable to conclude that a good choice for a well-designed collector for the city of Recife-PE, Brazil is: (a) east–west orientation; (b) receiver vertex angles (γ) of the order of (65°); (c) acceptance angle of the CPC ($\theta_a = 30°$) and (d) concentration of the truncated cavity (C_t) in the interval (1.0–1.2).

08/02064 Assessment of elements, speciation of As, Cr, Ni and emitted Hg for a Canadian power plant burning bituminous coal

Goodarzi, F. *et al. International Journal of Coal Geology*, 2008, 74, (1), 13–27.

A detailed assessment of elements was carried out at a power plant rated at 150 MW burning western Canadian medium volatile bituminous coal with an ash content of 34 wt.%. The distributions of elements of environmental concern (As, Cd, Cr, Hg, Ni and Pb) in feed coals, ashes, and stack-emitted materials were determined using NAA, ICPES and ICP-MS, GFAA for Pb, and CVAA for Hg. The speciation of As, Cr, and Ni was examined using XANES spectroscopy. The results show that the elements in the feed coal are within the same range for As, Hg and Pb and higher for Cd, Cr and Ni compared to other Canadian feed coals and within range for world coals. The combination of a mechanical cyclone separator (MCS) and fabric filter (FF) removes a significant portion of the elements of environmental concern, as indicated by their relative enrichment ratios greater than 0.7. The fly ash from within the FF has a higher content of elements, such as Hg (1.58 mg/kg) than the MSC (0.13 mg/kg) due its lower temperature (130 °C) and the ability for finer particles to be captured by the baghouse. Arsenic in the feed coal is dominated by arsenical pyrite and less toxic As^{+5} in arsenate forms. Arsenic is very low in the bottom ash, while in the fly ash it is largely (>90%) present as As^{+5}. Chromium in the milled coal is present as Cr^{+3} in association primarily with illite. This occurrence gives rise to an aluminosilicate association in ash materials, with the chromium oxidation state remaining as Cr^{+3}. Nickel in both the feed coal and ashes occurs as Ni^{+2} predominantly in coordination with oxygen. No evidence for carcinogenic Ni sub-sulfides was observed. Mercury is emitted from the plant at a rate of 1.8 g/h and is mostly in the form of reactive gaseous mercury, followed by elemental mercury and particulate mercury. The rates of input of elements of environmental concern, As, Cd, Cr, Hg, Ni and Pb, for this station were 10.45, 1.13, 123.3, 0.29, 36.3 and 23.1 kg/day, respectively, of which only 0.08, 0.01, 0.71, 0.04, 0.44, and 0.17 kg/day were emitted from the stack. Indicating that most of these elements (>99%) were captured by the particulate removing devices. The concentrations of elements in the air and in the vicinity of this power plant are low or within the range of published data for ambient air in urban and rural areas.

08/02065 Batch reactor optimization under liquid swelling safety constraint

Simon, L. L. *et al. Chemical Engineering Science*, 2008, 63, (3), 770–781.

This article presents the modelling and optimization of an industrial batch reactor operation with regard to production safety constraint which is represented by the reactor content swelling. Swelling occurs due to the evacuation of a coupled product which passes through the liquid in order to reach the reaction mass surface. In order to model the reaction system a chemical model linked to a hydrodynamic model is developed. The goal of the optimization is to calculate the temperature and pressure profiles which maximize conversion rates, without exceeding the maximum reactor level. The optimal temperature profile is calculated using the optimal control optimization method and the results show that a productivity increase of up to 36% can be achieved as compared to the industrial process.

08/02066 CFD modeling of hydrodynamic and heat transfer in fluidized bed reactors

Behjat, Y. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (3), 357–368.

In this study, a gas–solid fluidized bed reactor has been simulated applying CFD techniques in order to investigate hydrodynamic and heat transfer phenomena. Reactor model predictions were compared with corresponding experimental data reported in the literature to validate the model. The results indicate that considering two solid phases, particles with smaller diameters have lower volume fraction at the bottom of the bed and higher volume fraction at the top of the bed. In addition, it was revealed that bed expansion was larger when a bimodal particle mixture was applied compared with the case of mono-dispersed particles. Gas and solid phase temperature distributions in the reactor were also computed, considering the hydrodynamic of the fluidized bed and the heat generated by the solid particles. The results showed that gas temperature increases as it moves upward in the reactor due to the heat of polymerization reaction leading to the higher temperatures at the top of the bed.

08/02067 Combustion of olive cake and coal in a bubbling fluidized bed with secondary air injection

Varol, M. and Atimtay, A. T. *Fuel*, 2007, 86, (10–11), 1430–1438.

Combustion performances and emission characteristics of olive cake and coal are investigated in a bubbling fluidized bed. Flue gas concentrations of O_2, CO, SO_2, NO_x, and total hydrocarbons (C_mH_n) were measured during combustion experiments. Operational parameters [excess air ratio (λ), secondary air injection] were changed and variation of pollutant concentrations and combustion efficiency with these operational parameters were studied. The temperature profiles measured along the combustor column was found higher in the freeboard for olive cake than coal due to combustion of hydrocarbons mostly in the freeboard. Combustion efficiencies in the range of 83.6–90.1% were obtained for olive cake with λ of 1.12–2.30. For the setup used in this study, the optimum operating conditions with respect to NO_x and SO_2 emissions were found as 1.2 for λ, and 50 L/min for secondary air flowrate for the combustion of olive cake.

08/02068 Comparative study of heat transfer and wetting behaviour of conventional and bioquenchants for industrial heat treatment

Fernandes, P. and Prabhu, K. N. *International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 526–536.

An investigation was conducted to study the suitability of vegetable oils as bioquenchants for industrial heat treatment. The study involved the assessment of the severity of quenching and wetting behaviour of conventional and vegetable oil quench media. Quench severities of sunflower, coconut and palm oils were found to be greater than mineral oil. The quench severity of aqueous media is greater than oil media although their wettability is poor as indicated by their higher contact angles. A dimensionless contact angle parameter defined in this work is found to be a better parameter to compare the wetting behaviour with heat transfer.

08/02069 Comparison of the effectivities of two-phase and single-phase anaerobic sequencing batch reactors during dairy wastewater treatment

Göblös, S. *et al. Renewable Energy*, 2008, 33, (5), 960–965.

The performances of anaerobic sequencing batch reactors fed with two different substrates were studied. The substrates were raw acid whey and acid whey fermented with *Kluyveromyces lactis* in order to investigate the suitability of ethanol for biogas production. The organic loading rates (OLRs) during the experiment ranged from 1.6 to 12.8 $g\,COD\,dm^{-3}\,d^{-1}$ and the corresponding decreasing hydraulic retention times from 40 to 5 days for both reactor systems. The efficiency of each system depended on the OLR: the highest COD removal rate was observed at the lowest OLR applied (about 100% in both systems), and at maximum OLR the COD removal efficiency was 68% for the reactors fed with the raw whey and 80% for those fed with the pre-fermented whey. Under the same high OLR conditions the methane yield was 0.122 $dm^{-3}\,CH_4\,g^{-1}\,COD_{degraded}$ for the anaerobic digesters fed with the untreated whey, and 0.197 $dm^{-3}\,CH_4\,g^{-1}\,COD_{degraded}$ for those fed with the pre-fermented whey. The digesters functioned without pH control. At the maximum OLR the pH in the reactors fed with the raw acid whey was 5.1, while in those fed with the pre-fermented whey it was 7.15. The results demonstrate that the use of the pre-fermented acid whey as substrate for anaerobic digestion without pH control is feasible, especially at high OLR levels. This substrate is preferable to the raw acid whey, because of the ethanol formed as a non-acidic fermentation product of the yeast.

08/02070 Computer aided kinetic modeling with KMT and KME

Wei, W. *et al. Fuel Processing Technology*, 2008, 89, (4), 350–363.

The complexity of many chemical and refining reaction systems and the thus-derived tedious and time-consuming process of building the associated kinetic models have been major obstacles in the use of fundamental kinetics in the solution of chemical engineering problems. This review summarizes work aimed at removing theses obstacles. The recent work that has led to the enhancement of the kinetic modeller's toolbox and the development of the kinetic model editor presents an end-to-end solution to the kinetic modelling process, including automated feedstock modelling, reaction network construction, kinetic rate estimation, model programming, process system configurations, model customizations, compilations, model execution and results analysis.

08/02071 Efficiency of an integrated gasification combined cycle (IGCC) power plant including CO_2 removal

Descamps, C. *et al. Energy*, 2008, 33, (6), 874–881.

This study is devoted to technical evaluation of a carbon dioxide removal in an existing integrated gasification combined cycle (IGCC) plant. This IGCC case is based on an oxygen blown entrained flow gasifier operating at 27 bar, the removal of acid gas (H_2S) is performed with MDEA unit, the efficiency of this IGCC is 43% based on the low heating value of coal. A carbon dioxide separation unit conveniently integrated in a pre-combustion separation process is chosen, in order to take advantage of the high pressure of the gas. The methanol process for carbon dioxide removal is integrated downstream the existing desulfuration unit, and after a CO shift conversion unit. In this study, the integration of the CO_2 capture process to the IGCC is simulated as realistically as possible. The design parameters of both the gas turbine (the turbine inlet temperature, compressor pressure ratio, reduced flow rate) and the steam turbine (Stodola parameter) are taken into account. Maintenance of low NO_x production in the combustion chamber is also considered. The production of NO_x is supposed to be influenced by the low heating value of the gas which is maintained as low as for case of the synthesis gas without CO_2 capture. Thus the choice is made to feed the gas turbine of the combined cycle with a diluted synthesis gas, having similar low heating value than the one produced without the CO_2 capture. Plant performances for different conversion and capture rates are compared. A final optimized integration is given for 92 mol% CO conversion rate and 95 mol% CO_2 absorption rates, a comparison with former studies is proposed.

08/02072 European emission trading scheme and competitiveness: a case study on the iron and steel industry

Demailly, D. and Quirion, P. *Energy Economics*, 2008, 30, (4), 2009–2027.

In this paper, the authors quantify the impact of the European Emission Trading Scheme (ETS) on the two dimensions of competitiveness – production and profitability – for the iron and steel industry. Among those covered by the scheme, this sector is one of the most exposed, since it is both highly CO_2-intensive and relatively open to international trade. The robustness of these results is also examined to various assumptions: marginal abatement cost curve, trade and demand elasticities, as well as pass-through rates and updating of allocation rules, of which the latter two are scarcely debated. It is concluded that for this sector, competitiveness losses are small. It is proven that this conclusion to be robust. Hence arguments against tightening the environmental stringency of the ETS in Phase II are not justified on grounds of competitiveness loss. The systematic sensitivity analysis allows us to identify the important assumptions for each output variable. It turns out that pass-through rates and updating rules are significant, despite being often implicit and least debated in existing analyses.

08/02073 Exergy analysis on the irreversibility of rotary air preheater in thermal power plant

Wang, H. Y. *et al. Energy*, 2008, 33, (4), 647–656.

Energy recovery devices can have a substantial impact on process efficiency and their relevance to the problem of conservation of energy resources is generally recognized to be beyond dispute. One type of such a device, which is commonly used in thermal power plants and air conditioning systems, is the rotary air preheater. A major disadvantage of the rotary air preheater is that there is an unavoidable leakage due to carry over and pressure difference. There are gas streams involved in the heat transfer and mixing processes. There are also irreversibilities, or exergy destruction, due to mixing, pressure losses and temperature gradients. Therefore, the purpose of this research paper is based from the second law of thermodynamics, which is to build up the relationship between the efficiency of the thermal power plant and the total process of irreversibility in the rotary air preheater using exergy analysis. For this, the effects of the variation of the principal design parameters on the rotary air preheater efficiency, the exergy efficiency, and the efficiency of the thermal power plant are examined by changing a number of parameters of rotary air preheater. Furthermore, some conclusions are reached and recommendations are made so as to give insight on designing some optimal parameters.

08/02074 Firing of coal and biomass and their mixtures in 50 kW and 12 MW circulating fluidized beds – phenomenon study and comparison of scales

Nevalainen, H. *et al. Fuel*, 2007, 86, (14), 2043–2051.

The combustion dynamics of coal, wood chips and their mixture areinvestigated. Load change capability and the effect of the individual control variables, for example the mixture ratio of different fuels, on pilot-scale circulating fluidized bed (CFB) boiler dynamics were also studied. Disturbances in fuel feeding cause fluctuations in the flue gas concentrations. Changes in the heating value are possible due to varying moisture content of the fuel. Both these disturbances affect the instantaneous firing rate in a boiler. Also the characteristics of the fuels have to be taken into consideration when designing boiler control systems. When co-firing two fuels with clearly distinct combustion characteristics, direct assumptions based on each fuel's characteristics cannot be made about combustion behaviour of their mixture. Combustion experiments with coal and wood chips and their co-firing were carried out in a pilot-scale CFB reactor (VTT) and a large-scale CFB boiler (Chalmers). A comparison of the combustion in the two different size reactors, provides information about scaling. The combustion responses due to changes in the fuel feeding of the two circulating fluidized beds are analysed by a dynamic model.

08/02075 Industrial symbiosis of very large-scale photovoltaic manufacturing

Pearce, J. M. *Renewable Energy*, 2008, 33, (5), 1101–1108.

In order to stabilize the global climate, the world's governments must make significant commitments to drastically reduce global greenhouse gas (GHG) emissions. One of the most promising methods of curbing GHG emissions is a world transition from fossil fuels to renewable sources of energy. Solar photovoltaic (PV) cells offer a technically sustainable solution to the projected enormous future energy demands. This article explores utilizing industrial symbiosis to obtain economies of scale and increased manufacturing efficiencies for solar PV cells in order for solar electricity to compete economically with fossil fuel-fired electricity. The state of PV manufacturing, the market and the effects of scale on both are reviewed. Government policies necessary to construct a multi-gigaWatt PV factory and complementary policies to protect existing solar companies are outlined and the technical requirements for a symbiotic industrial system are explored to increase the manufacturing efficiency while improving the environmental impact of PV. The results of the analysis show that an eight-factory industrial symbiotic system can be viewed as a medium-term investment by any government, which will not only obtain direct financial return, but also an improved global environment. The technical concepts and policy limitations to this approach were analysed and it was found that symbiotic growth will help to mitigate many of the limitations of PV and is likely to catalyse mass manufacturing of PV by transparently demonstrating that large-scale PV manufacturing is technically feasible and reaches an enormous untapped market for PV with low costs.

08/02076 Integration of a heat pump into the heat supply system of a cheese production plant

Kapustenko, P. O. *et al. Energy*, 2008, 33, (6), 882–889.

The food processing industry in Ukraine is widely developed and continues to develop. The majority of the enterprises of the food processing industry use the technological process with refrigerating cycles. Basically it uses ammonia refrigeration units. In existing ammonia refrigeration units waste energy from ammonia overheat after compression is not used. This waste energy can be used for heating of other technological streams. It can be achieved by detailed inspection of the technological streams system and further heat integration of the ammonia unit into a heating system of the enterprise. In this study an inspection of a cheese production plant has been conducted and the opportunity to heat integration of an existing ammonia refrigeration unit into technological process is considered. At present energy from ammonia superheating and condensation is not used and is expelled into the atmosphere through the cooling tower. There are two options for use of this heat: first without additional compression of ammonia and second with additional compression of ammonia stream. Both cases are considered.

08/02077 Latent heat storage above 120°C for applications in the industrial process heat sector and solar power generation

Tamme, R. *et al. International Journal of Energy Research*, 2008, 32, (3), 264–271.

This paper is focused on thermal storage technologies using phase change materials (PCMs) in the temperature range of 120–300°C for solar thermal power generation and high temperature process heat. As the state-of-the-art reference system a steam accumulator is described, which typically has a volume-specific thermal energy density of 20–30 $\mathrm{kWh\,m^{-3}}$. Regarding efficiency, a fundamental demand on thermal storage is the minimization of temperature differences between working fluid and storage medium. This requires isothermal storage systems for processes using water/steam. An obvious solution is, therefore, the application of PCMs. The selection of the PCMs depends strongly on the operation conditions of the respective application. At present, the main emphasis is directed to alkali metal nitrates and nitrites and their mixtures. For example, the eutectic mixture of the binary system KNO_3–$NaNO_3$ has been identified as an excellent system to be used for processes using saturated steam at around 25 bar. At around 5 bar the ternary system KNO_3–$NaNO_2$–$NaNO_3$, commonly used as heat transfer fluid, can also be used as a PCM. To overcome the low thermal conductivity of the salt systems, approaches of increased surfaces area and increased thermal conductivity using expanded graphite (EG) have been investigated. Using EG/PCM composites, the effective thermal conductivity can be increased from below 0.5 to 2–20 $\mathrm{W\,(mK)^{-1}}$. Three design concepts have been developed. In the macro-encapsulated design, the PCM is enclosed in metal tubes, giving a short distance for heat transfer and increasing the heat transfer area. In the second design, the heat exchanger tubes are embedded in EG/PCM-composite storage material. The third design option uses graphite foils arranged perpendicularly onto the heat exchanger tubes and a suitable salt system filled in between. The upgrade of existing steam accumulators using these PCM concepts is also proposed.

08/02078 Modelling the combustion of pulverized biomass in an industrial combustion test furnace

Ma, L. *et al. Fuel*, 2007, 86, (12–13), 1959–1965.

A CFD model that simulates the combustion of biomass in existing pf coal fired furnaces has been developed and model results for the combustion of a typical wood in a 1 MW industrial test facility have been presented. The model is primarily based on coal combustion submodels using an Eulerian–Lagrangian frame of reference. Biomass specific constants that define the submodels have been investigated and employed in the simulation. In particular, potassium release during biomass combustion and the formation of NO_x have been simulated. Numerical predictions have been compared with some experimental measurements that have been taken and reasonably good agreement has been achieved.

08/02079 Multi-stage axial flow compressors characteristics estimation based on system identification

Ma, W. *et al. Energy Conversion and Management*, 2008, 49, (2), 143–150.

The most troublesome part in the development of a component-based engine models is the compressor module because of the strong dependence of its performance on rotational speed. For this purpose, a performance characteristics estimation method of multi-stage axial flow compressors are proposed in this paper. The newly proposed estimation technique of average infinitesimal stage characteristics satisfies the analogy criterion perfectly due to the use of a new conception of infinitesimal stage and the improved analogy theory. The overall compressor performance characteristics are estimated through a stage by stage calculation based on the improved analogy theory and the average stage characteristics. To minimize the error between the calculated characteristic and the tested characteristic of the compressor at high rotational speeds, the average stages performance characteristics are identified using an optimization method. The technique improves the traditional scaling method by taking into account the effects of air density change and rotational speeds, and it makes use of available data efficiently. In addition, it reflects the own performance characteristics of the original compressor.

08/02080 Strength tests of axially symmetric perforated plates for chemical reactors: part 1 – the simulation of stress state

Achtelik, H. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (4), 248–256.

In this paper, the authors propose a mathematical approach to determine the internal forces in a perforated circular plate of the heat exchanger of a chemical reactor. The plate underwent loading, which was symmetrical about the central plate axis and perpendicular to the central surface of the plate. The assumed mathematical algorithm allows evaluation of the stress state in the perforated plate by means of analytical relations.

08/02081 Strength tests of axially symmetric perforated plates for chemical reactors: part 2 – experiments

Achtelik, A. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (4), 257–264.

The aim of the present paper is to elaborate the methodology of empirical studies, which would allow establishing stress histories in perforated plates centrally loaded by a concentrated force. The other objective is to empirically verify the mathematical model proposed in a companion paper (part 1). The diameter of the holes, as well as the geometry of their distribution in the plate prepared for the study, provided for the constancy of section-weakening coefficients. Some resistance strain gauges were placed in between the holes in order to measure the strains. The axially symmetric perforated plate was subjected to bending with a concentrated force applied centrally. Additionally, bending of the plate was monitored with a dial gauge during the measurements of the strains. On the basis of the measured values of the strains the authors were able to establish radial, circumferential and equivalent stresses in the plate. The empirical research corroborated the correctness of the adopted model of calculating the stress states in the perforated plate.

08/02082 The effect of combined viscous dissipation and Joule heating on unsteady mixed convection MHD flow on a rotating cone in a rotating fluid with variable properties in the presence of Hall and ion-slip currents

Osalusi, E. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (4), 413–429.

This paper is concerned with the effect of combined viscous dissipation and Joule heating on unsteady mixed convention magnetohydrodynamics (MHD) flow on a rotating cone in an electrically conducting rotating fluid in the presence of Hall and ion-slip currents. The fluid properties [density, (ρ), viscosity, (μ) and thermal conductivity, (κ)] are taken to be dependent on temperature and a strong uniform magnetic field is applied in the z-direction. It has been shown that a self-similar solution is possible when the free stream angular velocity and the angular velocity of the cone vary inversely as a linear functions of time. The unsteady Navier–Stokes equations along with the energy equation are reduced to a system of ordinary differential equations by using similarity transformations and the resulting equation system is solved numerically by using a shooting method. Results for the details of the velocity as well as temperature are shown graphically and the numerical values of the skin friction and the rate of heat transfer are entered in tables.

08/02083 Unsteady heat transfer from an elliptic cylinder

Juncu, G. *International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 920–928.

Numerical methods are used to investigate the transient heat transfer from an elliptic cylinder to a steady stream of viscous, incompressible fluid. The temperature of the cylinder is considered spatially uniform but not constant in time. The momentum and heat balance equations were solved numerically in elliptic coordinate system. The solutions span the parameter ranges $5 \geq Re \geq 40$, $1 \geq Pr \geq 100$ and axis ratio e, $0.1 \geq e \geq 0.75$. The computations were focused on the influence of the axis ratio and volume heat capacity ratio on the heat transfer rate.

08/02084 Using the low-temperature Clausius–Rankine cycle to cool technical equipment

Nowak, W. *et al. Applied Energy*, 2008, 85, (7), 582–588.

The suitability of the low-temperature cycle of a vapour power-plant based on an organic fluid for cooling technical equipment that requires cooling during operation, e.g. power transformers, has been presented. The stream of the intermediate fluid, usually oil, which removes heat from the equipment being cooled is the upper heat reservoir of a power plant based on the Clausius–Rankine cycle. The byproduct of the operation of such an installation is electricity, which can be used to drive the fan cooling tower of the power plant. The assumed working parameters of the cycle, and mainly the criteria for selecting the organic working-fluid, whose properties have a major impact on the operating effectiveness of the solution, are proposed.

10 SPACE HEATING AND COOLING/HEAT PUMPS

08/02085 A development of easy-to-use tool for fault detection and diagnosis in building air-conditioning systems

Song, Y. *et al. Energy and Buildings*, 2008, 40, (2), 71–82.

There are many reports about faulty status in building air-conditioning systems recently. It becomes difficult to keep indoor air temperature appropriately as faults occur, and the faults cause waste of building energy consumption. The model-based fault detection and diagnosis (FDD) methods have been researched for specific parts of air-conditioning system such as chillers, coils, variable air volume units, etc. It needs, however, much time and labor to monitor and check every single part because the authors cannot predict where and when the faults occur. The purpose of this study is to examine indoor air temperature changes and energy consumption increase when faults occur and to develop an easy-to-use FDD tool that helps to find out the faulty place through the whole building air-conditioning system. And then, the authors treat the reliability of the proposed FDD tool and effectiveness to control of indoor environment deterioration and energy consumption increase by the tool is evaluated based on building air-conditioning system simulation in this paper.

08/02086 A new approach to the exergy analysis of absorption refrigeration machines

Morosuk, T. and Tsatsaronis, G. *Energy*, 2008, 33, (6), 890–907.

Splitting the exergy destruction into endogenous/exogenous and unavoidable/avoidable parts represents a new development in the exergy analysis of energy conversion systems. This splitting improves the accuracy of exergy analysis, improves the understanding of the thermodynamic inefficiencies and facilitates the improvement of a system. An absorption refrigeration machine is used here as an application example. This refrigeration machine represents the most complex type of a refrigeration machine, in which the sum of physical and chemical exergy is used for each material stream.

08/02087 A one-dimensional transient analytical model for earth-to-air heat exchangers, taking into account condensation phenomena and thermal perturbation from the upper free surface as well as around the buried pipes

Cucumo, M. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 506–516.

A one-dimensional transient analytical model is proposed to estimate the performance of earth-to-air heat exchangers, installed at different depths, used for building cooling/heating. Two independent space coordinates are considered, one in the longitudinal direction of the buried pipe and the other through the soil, in the vertical direction. With appropriate simplifications, analytical treatment is proposed to predict the temperature fields of the fluid in the pipe and of the soil in the proximity of the buried pipe, taking into account thermal perturbation of the upper free surface and the possible phase change (condensation) in the buried pipes. Moreover, the agreement with some experimental data available in the literature is very satisfactory.

08/02088 Analytical solutions of coupled heat and mass transfer processes in liquid desiccant air dehumidifier/regenerator

Liu, X. *et al. Energy Conversion and Management*, 2007, 48, (7), 2221–2232.

The dehumidifier and regenerator are key components in liquid desiccant air conditioning systems. Many researchers have developed mathematical models of the coupled heat and mass transfer processes in the dehumidifier or regenerator, and most of the models were solved numerically. Compared with numerical solutions, analytical solutions have more advantages in analysing the parameters that affect the heat and mass transfer performance. This paper presents analytical solutions of the air and desiccant parameters inside the parallel flow, counter flow and cross flow dehumidifier/regenerator under some reasonable assumptions based on the available heat and mass transfer models. The analytical solutions of the air and desiccant parameters within the dehumidifier/regenerator show good agreement with the corresponding numerical results, and the analytical solutions of the enthalpy and moisture efficiencies agree well with experimental findings. The method developed here can be used in the optimal design of the dehumidifier or regenerator.

08/02089 Assessment of Bejan's heat exchanger allocation model under the influence of generalized thermal resistance, relaxation effect, bypass heat leak and internal irreversibility

Pramanick, A. K. and Das, P. K. *International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 474–484.

This article reports an analytical investigation of the optimal heat exchanger allocation and the corresponding efficiency for maximum power output of a Carnot-like heat engine. To mimic a real engine, the generalized power law for the resistance in heat transfer external to the engine, relaxation effect in heat transfer, bypass heat leak and finally internal irreversibility of the power producing compartment of the engine is taken into consideration. From the engineering perspective the temperature ratio of the heat source and sink as well as to that of hot end and cold side of the working fluid is considered not to be the controllable parameters. A parametric study is presented for the other possible controllable variables. Selection of a power law over a linear model has a significant effect on the optimal heat exchanger allocation for maximum power output and the corresponding efficiency. For a higher degree of relaxation effect the drop in the maximum power efficiency is prominent along with the shift of equipartitioned allocation of heat exchanger inventory. Bypass heat leak and internal irreversibility exhibits relatively less pronounced effects on the maximum power efficiency and on the optimal heat exchanger allocation. Thus the endoreversible formulation of thermodynamic model is physically realistic. Strikingly when the optimal allocation of the heat exchanger inventory obeys the principle of equipartition in macroscopic organization for the linear law of the external heat resistance, the thermal efficiency appears to assume the representative documented value. Hence the linear model due to Bejan is also capable of capturing the essential features of a real power plant.

08/02090 Building energy simulation using multi-years and typical meteorological years in different climates

Yang, L. *et al. Energy Conversion and Management*, 2008, 49, (1), 113–124.

Detailed hourly energy simulation was conducted for office buildings in the five major climate zones – severe cold, cold, hot summer and cold winter, mild and hot summer and warm winter – in China using multi-year (1971–2000) weather databases as well as typical meteorological years (TMY). The primary aim was to compare the energy simulation results from the TMY with those from individual years and their long term means. A total of 154 simulation runs were performed. Building heating and cooling loads, their components and energy use for heating, ventilation and air-conditioning were analysed. Predicted monthly load and energy consumption profiles from the TMY tended to follow the long term mean quite closely. Mean bias errors ranged from –4.3% in Guangzhou to 0% in Beijing and root-mean-square errors from 3% in Harbin to 5.4% in Guangzhou. These percentages were not always the smallest compared with the 30 individual years, however, they are at the lower end of the percentage error ranges. This paper presents the work and its findings.

08/02091 Cold storage with ice slurries

Egolf, P. W. *et al. International Journal of Energy Research*, 2008, 32, (3), 187–203.

The storage of 'cold' with ice slurries – a special type of thermally multi-functional fluids or phase change slurries (PCS) – is discussed. At first an example of a calculation of a thermal energy storage tank is an ice slurry system with a peak load demand is presented. Then a new concept of ice slurry storage without mixing is introduced. It leads to ice particle stratification and front propagation in the storage vessel. The stratification of ice particles in ice slurry is theoretically described by multi-component multi-phase fluid dynamics. The resulting stratification process is calculated and front propagation times are compared with experimental results; they compare fairly well.

08/02092 Control of thermally-activated building systems (TABS)

Gwerder, M. *et al. Applied Energy*, 2008, 85, (7), 565–581.

Integrating the building structure to act as an energy-storage, thermally activated building system (TABS) has proved to be energy efficient and economically viable for cooling and heating of buildings. However control has remained an issue to be improved. In this paper, a method is outlined allowing both for dimensioning and for automated control of TABS, with automatic switching between cooling/heating modes for variable comfort criteria. The method integrally considers both HVAC and building automation design aspects, as well as the fact that during design and operation heat-gains are unknown, but that bounds of them normally can be specified. This integral method is termed the 'unknown-but-bounded' or UBB method. Applying the method guarantees that comfort can be maintained, as long as the actual heat-gains stay within the predefined range between the lower and upper bounds. The UBB method can also handle non-predictable day-to-day variations as well as room-to-room variations of the heat gains. The paper outlines the underlying thermal models and assumptions, and gives the procedure and an example for the application of the method.

08/02093 Design and operation of an air-conditioning system fueled by wood pellets

Kai, T. *et al. Renewable Energy*, 2008, 33, (4), 720–725.

A room-cooling system of 2 kW capacity fueled by wood pellets was designed, built and tested. The system was demonstrated during summer at the Yakushima Field Station of Kagoshima University, Japan. It contained a pellet feeder, a pellet burner, a heat exchanger, a lithium bromide–water absorption heat pump and a control unit. The volume of the test room was 36.9 m^3 and ambient temperature 30 °C. The airflow temperature from the room unit was decreased to 16 °C by the system, and the room temperature could be successfully controlled to 24 °C steady state. Room heating in winter was also demonstrated. Since the air was heat exchanged, the overall energy efficiency of the cooling system was low at about 19%. However, the calculation based on the heat flow showed that the efficiency could be enhanced to about 75% by direct heating of the regenerator by the flue gas.

08/02094 Design and performance prediction of a novel double heat pipes type adsorption chiller for fishing boats

Wang, K. *et al. Renewable Energy*, 2008, 33, (4), 780–790.

A novel double heat pipe type adsorber, which uses compound adsorbent of $CaCl_2$ and expanded graphite to improve the adsorption performance, is designed. The double heat pipes are integrated into the adsorbers in order to solve the problem of the corrosion between seawater and the steel adsorber in ammonia system and improve the heat transfer performance of the adsorber. There are two kinds of heat pipes integrated with the adsorber. One is the split type heat pipe for heating the adsorber in desorption phase, the other one is the two-phase closed thermosyphon heat pipe for cooling the adsorber in adsorption phase. The performance of two-adsorber adsorption chiller integrated with double heat pipes is predicted. The heat transfer performance of the heat pipes can meet the heat demands for adsorption/desorption of the adsorbent when the heating/cooling time is 720 s and mass recovery time is 60 s. When the exhaust gas temperature is 550 °C, the cooling water temperature is 25 °C, the inlet and outlet chilled water is –10 and –15.6 °C, respectively; the simulation results show that the cooling power and COP of this adsorption system are 5.1 kW and 0.38, respectively.

08/02095 Development and preliminary evaluation of double roof prototypes incorporating RBS (radiant barrier system)

Chang, P.-C. *et al. Energy and Buildings*, 2008, 40, (2), 140–147.

Double-skin roof is known as a very effective way to reduce both the conduction and convection heat transfers from roof to the ceiling of building, on the other hand, radiant barrier system (RBS) is very effective in blocking the radiation heat transfer between roof and ceiling. In this study, prototypical double roofs inspired by the concepts of both double-skin structure and RBS technique was specifically designed to cut down the solar heat gain from roof. The effect of energy saving was experimentally measured. A double roof structure, formed by a roof plate and an aluminum foil-PP (polypropylene) board-RC slab, can achieve good performance of heat barrier and is highly recommended.

08/02096 Empirical correlations for lubricant side heat transfer and friction characteristics of the HPD type steel offset strip fins

Guo, H. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (3), 251–262.

This study presents the empirical correlations describing the lubricant side heat transfer and friction characteristics of the high pressure direction type steel offset strip fin pattern. A total of 36 samples containing approximately 523 data points are used in the regression analysis. The proposed heat transfer correlation can describe all test data within ± 10% with a mean deviation of 4.01% while the proposed friction correlation can describe 97.8% of all experimental data within ± 15% with a mean deviation of 5.68% in the low Reynolds number range of 30–500.

08/02097 Exergy analysis of double effect vapor absorption refrigeration system

Khaliq, A. and Kumar, R. *International Journal of Energy Research*, 2008, 32, (2), 161–174.

Energy and exergy analyses previously performed by the authors for a single effect absorption refrigeration system have been extended to double effect vapour absorption refrigeration system with the expectation of reducing energy supply as well as an interest in the diversification of the motive power employed by HVAC technologies. The total exergy destruction in the system as a percentage of the exergy input from a generator heating water over a range of operating temperatures is examined for a system operating on LiBr–H_2O solution. The exergy destruction in each component, the coefficient of performance (COP) and the exergetic COP of the system are determined. It is shown that exergy destructions occur significantly in generators, absorbers, evaporator and heat exchangers while the exergy destructions in condenser, evaporator, throttling valves, and expansion valves are relatively smaller within the range of 1–5%. The results further indicate that with an increase in the generator temperature the COP and ECOP increase, but there is a significant reduction in total exergy destruction of the system for the same. On the other hand, the COP and ECOP decrease with an increase in the absorber temperature while the total exergy destruction of the system increases significantly with a small increase in the absorber temperature. The results show that the exergy method can be used as an effective criterion in designing an irreversible double effect absorption refrigeration system and may be a good tool for the determination of the optimum working conditions of such systems.

08/02098 Experimental study of effect of an inner thermal curtain in evaporative cooling system of a cascade greenhouse

Shukla, A. *et al. Solar Energy*, 2008, 82, (1), 61–72.

In this paper experimental study has been carried out in a cascade greenhouse with inner thermal curtain to see the effect of thermal curtain. A thermal model has also been developed to predict the air temperature in a cascade greenhouse. The fan-pad system has been used for evaporative cooling and an inner thermal curtain has been used to divide the greenhouse in two zones. Experiments have been conducted in hot summer conditions at Solar Energy Park, IIT Delhi, New Delhi, India for empty greenhouse. Statistical analysis has been carried out to validate the agreement of experimental observations with predicted values. The values of the root mean square percent deviation and coefficient of correlation has been found out 9.0%, 0.90; 5.0%, 0.95 and 7.0%, 0.97 for April, May and June in case of evaporative cooling without curtain in greenhouse-2. The degree of freedom for the experimental work is 10.0. It is found that the use of evaporative cooling with a thermal curtain reduces the temperature of greenhouse by 5 °C and 8 °C in the second zone of greenhouse-1 and -2 in comparison to greenhouse without curtain in May.

08/02099 Experimental study of photovoltaic solar assisted heat pump system

Ji, J. *et al. Solar Energy*, 2008, 82, (1), 43–52.

A novel photovoltaic solar assisted heat pump (PV-SAHP) system has been proposed in this study. Performance tests with a range of condenser supply water temperature were conducted on an experimental rig. The dynamic performance of this PV-SAHP system in a 4-day period with very similar weather conditions was analysed and the influencing factors were identified. The results indicate that this PV-SAHP system has a superior coefficient of performance (COP) than the conventional heat pump system and at the same time, the photovoltaic efficiency is also higher. The COP of the heat pump was able to reach 10.4 and the average value was about 5.4. The average photovoltaic efficiency was around 13.4%. The highest overall coefficient of performance ($COP_{p/t}$), bringing into consideration both the photovoltaic and thermal efficiency, was about 16.1.

08/02100 Frost retardation of an air-source heat pump by the hot gas bypass method

Byun, J.-S. *et al. International Journal of Refrigeration*, 2008, 31, (2), 328–334.

This study is concerned with a hot gas (refrigerant) bypass method to retard the formation and propagation of frost in an air-source heat pump. The feasibility of the hot gas bypass method was investigated experimentally and the method's performance is compared with that of a normal, 1.12 kW capacity air-source heat pump system with no defrost equipment such as an electric resistance heater. Results indicate that the hot gas bypass method is useful for retarding the formation and growth of frost at the outdoor coil. The best performance is shown under a bypass refrigerant flow rate of 0.2 kg/min (20% of the whole system refrigerant flow rate). During 210 min of heat pump operation, the hot gas bypass method improved COP and heating capacity at an average of 8.5% and 5.7%, respectively, relative to the normal system.

08/02101 Heat transfer behaviors in round tube with conical ring inserts

Promvonge, P. *Energy Conversion and Management*, 2008, 49, (1), 8–15.

To increase convection heat transfer in a uniform heat flux tube by a passive method, several conical rings used as turbulators are mounted over the test tube. The effects of the conical ring turbulator inserts on the heat transfer rate and friction factor are experimentally investigated in the present work. Conical rings with three different diameter ratios of the ring to tube diameter ($d/D = 0.5, 0.6, 0.7$) are introduced in the tests, and for each ratio, the rings are placed with three different arrangements (converging conical ring, referred to as CR array, diverging conical ring, DR array and converging–diverging conical ring, CDR array). In the experiment, cold air at ambient condition for Reynolds numbers in a range of 6000–26,000 is passed through the uniform heat flux circular tube. It is found that the ring to tube diameter ratio and the ring arrays provide a significant effect on the thermal performance of the test tube. The experimental results demonstrate that the use of conical ring inserts leads to a higher heat transfer rate than that of the plain surface tube, and the DR array yields a better heat transfer than the others. The results are also correlated in the form of Nusselt number as a function of Reynolds number, Prandtl number and diameter ratio. An augmentation of up to 197%, 333%, and 237% in Nusselt number is obtained in the turbulent flow for the CR, DR and CDR arrays, respectively, although the effect of using the conical ring causes a substantial increase in friction factor.

08/02102 Improving thermal performance of the roof enclosure of heavy construction buildings

Ben-Nakhi, A. *et al. Applied Energy*, 2008, 85, (10), 911–930.

High heat flux through the enclosures of heavy building constructions during summer and winter seasons is of great concern with respect to energy-related economics and environmental issues. This paper demonstrates the importance of quantitative evaluation of enclosure design and proves the potential for substantial energy savings by minor alterations of conventional roof designs. These modifications include adding insulation layer(s), removing construction details and obstructing fluid flow within the attic cavity by partial or full vertical partition within the cavity. The CFD approach adopted for this purpose is based on a numerical study of steady, conjugate natural convection in the cavity of an attic of heavy construction buildings. Because of the flow characteristics, laminar and turbulent models were employed for summer and winter day boundary conditions, respectively. Steady state results based on the finite-volume method were obtained for Rayleigh number in the range 10^8–10^{10}. Representative results illustrating the effects of the proposed design modifications on the local and total Nusselt numbers at the indoor surfaces are presented and discussed for summer and winter day boundary conditions. The results show that considerable energy saving may be achieved via relatively simple design changes. It is also shown that adding an insulation layer does not necessarily translate into energy conservation, and that eliminating a minor design detail might have significant rewards in terms of energy savings.

08/02103 Interaction between natural convection and surface thermal radiation in tilted slender cavities

Alvarado, R. *et al. International Journal of Thermal Sciences*, 2008, 47, (4), 355–368.

In this paper a numerical investigation of the interaction between two modes of heat transfer, natural convection and surface thermal radiation, in a tilted slender cavity is studied. The bottom and top surfaces of the cavity are heated and cooled at constant temperatures, while its sidewalls remain thermally insulated. The studied parameters are: the Rayleigh number ($10^4 \leq Ra \leq 10^6$), the aspect ratio ($8 \leq A \leq 16$) and the inclination angle ($15° \leq \lambda \leq 35°$). The steady state 2-D governing equations have been solved by the finite volume method. All the inner surfaces are assumed to be gray diffuse emitters and reflectors of radiation. The numerical model was reduced and compared to cases reported in the literature finding a good agreement. Streamlines, isotherms and total Nusselt numbers as a function of Rayleigh number for different inclinations are presented. The interaction between the two modes of heat transfer reveals that the decoupling of two mechanisms of heat transfer is not possible; the performance of the flow patterns, the isotherms and the radiative behaviour on the walls was different for the uncoupled and coupled modes of heat transfer in the tilted slender cavity. The steady state results indicated that the radiative surface radiation coupled with natural convection modifies appreciably the flow patterns and the average heat transfer in the slender cavity. The total heat transfer increases when the inclination angle increases, except when the flow structure changes from the multi-cell to the unit-cell pattern. However, the total heat transfer decreases when the aspect ratio increases. A comprehensive correlation for the total Nusselt number has been proposed.

08/02104 Natural convection in an open square cavity with discrete heaters at their optimized positions

Müftüoglu, A. and Bilgen, E. *International Journal of Thermal Sciences*, 2008, 47, (4), 369–377.

In this article, optimum positions of discrete heaters are determined by maximizing the conductance and then studied heat transfer and volume flow rate with discrete heaters at their optimum positions. Continuity, Navier–Stokes and energy equations are solved by finite difference – control volume numerical method. The relevant governing parameters were: the Rayleigh numbers, *Ra* from 10^3 to 10^7, the cavity aspect ratio, $A = H/L = 1$, the heater size h/L from 0.05 to 0.20 and number of heaters from 1 to 3. It is found that the global conductance is as an increasing function of the Rayleigh number, the heater size and the number of heaters. Best thermal performance is obtained by positioning the discrete heaters closer to the bottom and closer to each other at the beginning of fluid flow. The configuration is not equidistance but follows a function of the Rayleigh number. The Nusselt number and the volume flow rate in and out the open cavity are also increasing functions of the Rayleigh number, the heater size and the number of heaters.

08/02105 New counter flow heat exchanger designed for ventilation systems in cold climates

Kragh, J. *et al. Energy and Buildings*, 2007, 39, (11), 1151–1158.

In cold climates, mechanical ventilation systems with highly efficient heat recovery will experience problems with condensing water from the extracted humid indoor air. If the condensed water changes to ice in the heat exchanger, the airflow rate will quickly fall due to the increasing pressure drop. Preheating the inlet air (outdoor air) to a temperature above 0 °C before it enters the exchanger is one solution often used to solve the problem, however, this method reduces the energy saving potential significantly. To minimize the energy cost, a more efficient way to solve the freezing problem is therefore desirable. In this paper, the construction and test measurements of a new counter flow heat exchanger designed for cold climates are presented. The developed heat exchanger is capable of continuously defrosting itself without using supplementary heating. Other advantages of the developed heat exchanger are low-pressure loss, cheap materials and a simple construction. The disadvantage is that the exchanger is big compared with other heat exchangers. In this paper, the new heat exchanger's efficiency is calculated theoretically and measured experimentally. The experiment shows that the heat exchanger is capable of continuously defrosting itself at outside air temperatures well below the freezing point while still maintaining a very high efficiency. Further analysis and development of a detailed simulation model of a counter flow air-to-air heat exchanger will be described in future articles.

08/02106 Numerical analysis of a cool-thermal storage system with a thermal conductivity enhancer operating under a freezing condition

Alawadhi, E. M. *Energy*, 2008, 33, (5), 796–803.

Enhancing the cooling process of water in a cool-thermal storage system is investigated in this paper. The system is utilized to cool air during on-peak power consumption hours to save energy. The system consists of parallel plates filled with water and triangular corrugated fins. A finite element model for the system is used to predict the cooling time of water for different water's initial temperatures, and also to study the effect of fins design on the cooling process. The result indicates that the aspect ratio of the triangular fin has a significant effect the cooling process of water, and cooling rate increases for the aspect ratio greater or less than 0.75. Temperature contours, average water temperature, and Nusselt number are presented for the cooling process.

08/02107 On the robustness, effectiveness and reliability of chemical and mechanical heat pumps for low-temperature heat source district heating: a comparative simulation-based analysis and evaluation

Ajah, A. N. *et al. Energy*, 2008, 33, (6), 908–929.

This paper provides a comparative study of two of the most promising heat upgrading technologies (the chemical and mechanical heat pumps). The simulation results reveal that for a low to medium energy demand, low-temperature heat source upgrading using the chemical heat pumps seems more promising than the mechanical heat pumps, while the mechanical heat pump is best suited for high energy demand space heating. In the simulation, use was made of an artificial low-temperature heat source (a nearby pharmaceutical industry waste heat) with source temperature state of between 25 and 35 °C as the feed to the upgrading units. The high energy demand (assumed to be able to serve the space heating energy requirements of a given locality) was estimated to be 923 TJ/annum at a consumer-side temperature level of about 95 °C. The selected most robust system (the mechanical heat pump-based process) for upgrading the low-temperature heat source at such given high energy demand has been conceptually designed.

08/02108 Optimization on indoor air diffusion of floor-standing type room air-conditioners

Liu, W. *et al. Energy and Buildings*, 2008, 40, (2), 59–70.

The indoor air diffusion of a typical office equipped with a floor-standing type air-conditioner (FSAC) in summer was evaluated and optimized. Two existing evaluation indexes, the air diffusion performance index and the energy utilization coefficient, were modified for their more reasonable application in the evaluation on air diffusion performance of a FSAC. And also, a new index, fast cooling effect index, was presented to evaluate the fast-cooling effect. Based on the indoor airflow simulation using computational fluid dynamics, the three indexes were applied to evaluate the air diffusion performance of the FSAC. As a result, the optimal indoor air diffusion types with best thermal feelings, fine energy utilization efficiency and excellent fast-cooling effect were obtained, and also, a control scheme was suggested.

08/02109 Performance analysis of a photovoltaic heat pump

Ji, J. *et al. Applied Energy*, 2008, 85, (8), 680–693.

A novel heat pump system is proposed in that the PV/T collector is coupled with a solar assisted heat pump and works as an evaporator. The cooling effect of the refrigerant allows the PV modules to work at lower temperature and so its photovoltaic efficiency is improved. Mathematical model has been developed to analyse the complex energy conversion processes. Numerical simulation was then performed based on the distributed parameters approach. An experimental rig was also built to verify the real performance of the system as compared to the simulation model prediction. The results indicated that this photovoltaic solar assisted heat pump (PV-SAHP) has better coefficient of performance (COP) and photovoltaic efficiency than the separate units. Under the experimental conditions, the COP of the PV-SAHP reached 8.4 and the average value was around 6.5, whereas the average photovoltaic efficiency was around 13.4%. The experimental results were found in good agreement with the theoretical predictions on the system responses to changing environmental conditions.

08/02110 Performance analysis of air cycle refrigerator integrated desiccant system for cooling and dehumidifying warehouse

Elsayed, S. S. *et al. International Journal of Refrigeration*, 2008, 31, (2), 189–196.

In this paper, the performance of air cycle refrigerator integrated desiccant system used to cool and dehumidify warehouse is analysed theoretically. Simulation analysis is carried out to calculate the system coefficient of performance, cooling effects and the humidity change under different values of pressure ratio, storage zone temperature inside dock and outdoor air conditions. Also, the effect of the air cycle and the rotor parameters on the system performance is evaluated. From the simulation result it is found that, the desiccant system has the ability to supply air to the dock area at very low humidity. The system coefficient of performance increases due to the exhaust heat recovery on the desiccant system, and this enhancement can be more than 100%. The coefficient of performance of the proposed system is greater than that of a conventional system under the same operating conditions.

08/02111 Performance comparison of air source heat pump with R407C and R22 under frosting and defrosting

Liu, Z. *et al. Energy Conversion and Management*, 2008, 49, (2), 232–239.

The dynamic performance characteristics of the air source heat pump with refrigerants R22 and R407C during frosting and defrosting are studied. The results show that both refrigerant systems have similar performance characteristics, except that the performance of the R407C system deteriorated faster than that of the R22 system under frosting, and the performance of the R407C system attains its steady state faster than that of the R22 system after defrosting. R407C refrigerant can be used in either existing systems or in new systems that were originally designed for R22.

08/02112 Performance evaluation of a non-adiabatic capillary tube in a transcritical CO_2 heat pump cycle

Agrawal, N. and Bhattacharyya, S. *International Journal of Thermal Sciences*, 2008, 47, (4), 423–430.

A non-adiabatic capillary tube in a transcritical CO_2 heat pump cycle has been simulated to investigate the effect of parameters such as gas cooler and evaporator temperature, capillary tube diameter and heat exchanger length on various performance indicators. The homogeneous flow model is employed to simulate two-phase flow in the non-adiabatic capillary tube. Fundamental equations of mass, energy and momentum are solved simultaneously through an iterative process. Single and two-phase heat transfer coefficients are calculated by employing appropriate empirical correlations. Subcritical and supercritical thermodynamic and transport properties of CO_2 are calculated employing an in-house precision property code. Lowering evaporator temperature is found to be more effective for heat transfer from the capillary tube compared to the gas cooler temperature. Heat transfer rate variation with respect to gas cooler temperature in case of CO_2 is distinctly different compared to conventional refrigerants due to its transcritical nature and is influenced by initial quality, mass flow rate of the refrigerant and the prevailing temperature difference at the gas cooler. Increase in gas cooler temperature causes the heat transfer rate to first increase and then to decrease. Lowering evaporator and gas cooler temperature increases the cooling capacity. Throttling effect decreases rapidly as internal tube diameter becomes larger leading to higher mass flow rate of the refrigerant. Shorter inlet adiabatic capillary length with larger heat exchanger length is better for heat transfer. This study is an attempt to allay the scepticism prevailing in the parlance of CO_2 based transcritical systems overemphasizing the need for a throttle valve to control the optimum discharge pressure.

08/02113 Performance improvement of vertical ice slurry generator by using bubbling device

Zhang, X. J. *et al. Energy Conversion and Management*, 2008, 49, (1), 83–88.

For the dynamic ice making system, a long outstanding problem is how to make ice continuously without adhesion to the cooling wall. In this paper, a bubbling device was applied to an experimental dynamic ice making system to suppress ice adhesion to the cooling wall. The experimental dynamic ice making system employed an air compressor to create air bubbles, and for the sake of this purpose, its ice slurry generator was set up vertically. To achieve an optimum working condition, a performance study on this system was conducted. The effects of the air blowing rate and other operating parameters on the performance were experimentally studied. It is concluded that the air bubbles are effective to suppress ice adhesion to the cooling wall; however, the air blowing rate of the air compressor should be optimized.

08/02114 Performance optimization for an irreversible four-temperature-level absorption heat pump

Huang, Y. *et al. International Journal of Thermal Sciences*, 2008, 47, (4), 479–485.

The optimal performance of an absorption heat pump operating between four temperature levels with the losses of heat resistance and internal irreversibility is analysed first by taking the total heat-transfer area of heat exchangers as an objective function. The minimum total heat-transfer area is described in terms of the rate of the entropy changes of four heat reservoirs, and the generally optimal relation among the heating load, the coefficient of performance and total heat-transfer area is achieved. Then, an ecological optimization criterion is proposed for the best mode of operation of the absorption heat pump. The authors investigate the ecological optimization performance and derive the optimal heating load, coefficient of performance and entropy production rate at the maximum ecological criterion for the absorption heat pump. Effects of thermal reservoir temperature and the internal irreversibility on the ecological function have been discussed.

08/02115 Performance simulation of refrigerated display cabinets operating with refrigerants R22 and R404A

Ge, Y. T. and Cropper, R. *Applied Energy*, 2008, 85, (8), 663–786.

This paper describes the analysis and performance comparison of a display cabinet system using refrigerant R404A and its substitute refrigerant R22. The model of the display cabinet is developed at steady state and integrated from three main component sub-models, air-cooling finned-tube evaporator, air curtain and display cabinet body. The evaporator model is built up based on the distributed method, which can simulate the heat exchangers with different circuit structures. The frost effect on the performance of the evaporator is included in the model. The correlations for the heat transfer and pressure drop calculations of both air and refrigerant sides are purposely selected in the evaporator model. In addition, the evaporator model has been validated with experimental results at steady states from published literature. Several correlated functions from the detailed numerical solution are used for the model of the air curtain. Some simplifications are also utilized for the model of display cabinet body. The performance simulation and comparison of the display cabinet using refrigerants R404A and R22 are carried out at different indoor ambient conditions especially at varied ambient air humidity to mimic the actual indoor space conditions in super stores. Some significant results such as the comparison of cooling load requirement for different refrigerant display cases have been obtained from the simulation, which can significantly contribute to the optimal cabinet design and operating analysis.

08/02116 Static mixers as heat exchangers in supercritical fluid extraction processes

Simões, P. C. *et al. The Journal of Supercritical Fluids*, 2008, 43, (3), 477–483.

The performance of a Kenics static mixer as a heat-transfer device for supercritical carbon dioxide (CO_2) flow is studied and compared with conventional tube-in-tube heat exchangers. Measurements were carried out at pressures ranging from 8 to 21 MPa, temperatures from 283 to 323 K, and mass flowrates from 2 to 15 kg/h. The corresponding Reynolds and Prandtl numbers, at bulk conditions, ranged between 10^3 and 2×10^4 and between 2 and 7, respectively. The temperature increase experienced by the supercritical CO_2 stream varied between 10 and 35 K. The heat fluxes obtained with the static mixer are one order of magnitude higher than the ones observed with a tube-in-tube heat exchanger for the same set of operating conditions. The heat-transfer enhancement is caused by the cross-sectional mixing of the fluid and to a lesser extent by conduction across the metallic mixing elements. Heat-transfer is also affected by temperature-induced variation of physical properties, especially in the pseudocritical region of the fluid. From the experimental data, a correlation was developed for convective heat-transfer to supercritical CO_2 in terms of the Nusselt number.

08/02117 Stay cool with less work: China's new energy-efficiency standards for air conditioners

Lin, J. and Rosenquist, G. *Energy Policy*, 2008, 36, (3), 1090–1095.

In response to electricity shortages, China announced a new set of minimum energy-efficiency standards for room air conditioners (RACs), with the first tier going into effect on 1 March 2005 and the second tier taking effect on 1 January 2009. This paper first reviews the requirements of the new Chinese standards for air conditioners and compares them to similar standards in other countries. It then presents results from an analysis of the cost-effectiveness of the standards and the impact of the new standards on energy savings, electric generation capacity, and CO_2 emissions reductions. China's recent efforts to regulate the efficiency of RACs will yield significant consumer economic savings as well as avoided construction of a large number of power plants and avoided emissions of GHG and other local pollutants.

08/02118 Study of an electrical heating system with ductless air supply and shape-stabilized PCM for thermal storage

Lin, K. *et al. Energy Conversion and Management*, 2007, 48, (7), 2016–2024.

A kind of electrical floor heating system with a shape-stabilized phase change material (PCM) which has been studied at Tsinghua University in the previous studies, can provide space heating during the whole day and can be controlled conventionally. However, this is not suitable for office buildings where no space heating is needed at night. The effective control is very important for the heating system in such buildings. In this paper, a kind of new electrical floor heating system is studied with ductless air supply and shape-stabilized PCM for thermal storage in order to overcome the shortcomings of the passive underfloor electric heating system with thermal storage. In this paper, the authors investigated its thermal performance by experiments and simulation, calculated the effects of various factors and discussed the application feasibility in different climate regions. The results show that the total electrical energy consumption was shifted from the peak period to the off-peak period, which would provide significant economic benefits because of the different day and night electricity tariffs. The system can be designed by choosing PCM with proper melting temperature and be controlled by varying velocity of air supply in different conditions.

08/02119 Swedish solar heated residential area with seasonal storage in rock: initial evaluation

Lundh, M. and Dalenbáck, J.-O. *Renewable Energy*, 2008, 33, (4), 703–711.

A partly solar heated building area comprising 50 residential units has been built in Anneberg, Sweden. The system includes low-temperature space heating with seasonal ground storage of solar heat. Heating is supplied by 2400 m^2 solar collectors and individual electrical heaters for supplementary heating. The ground storage comprises about

$60{,}000\,m^3$ of crystalline rock with 100 boreholes drilled to 65 m depth and fitted with double U-pipes. The collectors will have favourable working conditions but the store is rather small, the estimated heat loss from the heat store is about 40% of stored solar heat and the average solar fraction is estimated to 70% after 3–5 years of operation. An initial evaluation after 2 years of operation shows that, although problems have occurred and several parts seem to work less efficient than expected, the overall system idea works as intended.

08/02120 Temperature and entropy generation behavior in rectangular ducts with 3-D heat transfer coupling (conduction and convection)

Silva, R. L. and Garcia, E. C. *International Communications in Heat and Mass Transfer*, 2008, 35, (3), 240–250.

Temperature and entropy generation fields are evaluated for 3-D heat transfer coupling (conduction and convection) using a mathematical and computational model. Results are obtained from numerical simulation and analysed for conditions of fully developed laminar flow inside rectangular ducts. Thermal boundary conditions, at the walls cross section and axial direction, are non-uniform and not imposed. A numerical method of modified TDMA algorithm combined with an iterative solution for the system of algebraic equations obtained was developed. Equations were discretized by finite differences. Convergence is guaranteed by applying the first law of thermodynamics. Considering the thinness of the walls, conduction effectiveness is well represented as 1-D. The methodology applied considers air, water and oil as working fluids at 300 K and carbon-steel as wall material. Results for these cases are presented with the intention of finding, the best fluid heating conditions as a first approach to the design of heat exchangers systems.

08/02121 Testing solar collectors as an energy source for a heat pump

Georgiev, A. *Renewable Energy*, 2008, 33, (4), 832–838.

The article presents the experimental study of a heat pump possessing solar collectors as an energy source. A method to test the combined work of collectors delivering heat to the evaporator of a heat pump was devised. The layout of the test facility is shown and the system construction with the measurement equipment is described. The planning experiment to test the installation was chosen. The medium fluid condenser temperature i_c, the fluid condenser mass flow rate $\dot{m}_c$ and the medium fluid evaporator temperature i_{ev} were chosen as experiment factors to determine both objective functions – the coefficient of performance of the heat pump and the efficiency of the system η_s. The reverberation of both objective functions is shown.

08/02122 The effect of oil in refrigeration: current research issues and critical review of thermodynamic aspects

Youbi-Idrissi, M. *et al. International Journal of Refrigeration*, 2008, 31, (2), 165–179.

A lubrication agent is necessary in almost all the refrigeration vapour compression systems, particularly for the correct operation of the compressor. However, a certain portion of the oil always circulates with the refrigerant through the cycle. This circulation is at the origin of a deviation from the theoretical behaviour (i.e. based on pure refrigerant) of the components. This article aims at reviewing the oil-related researches in the field of refrigeration. Previous reviews in the literature focused on the thermo-hydraulic consequences of the presence of oil; the authors will analyse here its thermodynamical consequences. In a first part, a brief literature review will give an overview of current scientific and technological issues concerning the impact of oil on components or on whole refrigeration systems. The typical approaches and methods employed to address this problem will be described. These researches require sound tools for the evaluation of thermodynamic properties of refrigerant–oil mixtures. The second part of this article is hence a critical review of these tools, and focuses particularly on liquid–vapour equilibrium, absorption–diffusion, and mixture enthalpy calculation.

08/02123 The effects of roof reflectance on air temperatures surrounding a rooftop condensing unit

Wray, C. and Akbari, H. *Energy and Buildings*, 2008, 40, (1), 11–28.

Recent anecdotal information suggests that ‘cool’ roofs might produce significant energy savings by reducing the temperature of air entering rooftop air-conditioner (RTU) condensers. A set of six rigorous field experiments were carried out to determine the effects of roof reflectance on the heating of condenser inlet air by the roof, and to assess the effects of condenser fan operation on the potential recirculation of hot discharge air from the condenser. The experiments involved combinations of two roof conditions (a ‘hot’ roof and then the same roof with a ‘cool’ coating) and three RTU operation modes (condenser fan and compressor both operating, condenser fan operating without the compressor, and condenser fan and compressor both not operating). For each case, the authors continuously measured outdoor air temperature at 26 locations near and far from the RTU, as well as roof surface temperatures at two locations (one near and one far from the RTU), wind speed and direction, and solar radiation. With a ‘hot’ roof and the compressor and condenser fan both operating, the air temperature at the condenser inlet was only 0.3 °C warmer on average during peak solar radiation times compared with a reference located far from the RTU. Applying a ‘cool’ roof coating around the RTU eliminated this small temperature rise. The temperature rise was not significantly different when the condenser fan operated without the compressor, which suggests that hot air discharged by the condensing unit was not recirculated. Based on published relationships for cooling capacity and system power versus condenser inlet air temperature (normalized, respectively, by the capacity and power at the ARI outdoor temperature rating point of 35 °C), the 0.3 °C reduction in inlet air temperature associated with installing a cool roof corresponds to a decrease in RTU energy consumption of about 0.3–0.6% and an increase in EER of about 0.6–0.7%. Energy codes such as ASHRAE Standards 90.1 and 90.2 and California Title 24 already include energy saving credits related to cool roofs. Additional energy savings from reducing condenser inlet air temperature by installing a cool roof would only slightly increase these credits.

08/02124 Thermoeconomic optimization for a finned-tube evaporator configuration of a roof-top bus air-conditioning system

Mansour, M. K. *et al. International Journal of Energy Research*, 2008, 32, (4), 290–305.

This paper presents a methodology of a design optimization technique that can be useful in assessing the best configuration of a finned-tube evaporator, using a thermoeconomic approach. The assessment has been carried out on a direct expansion finned-tube evaporator of a vapour compression cycle for a roof-top bus air-conditioning (AC) system at a specified cooling capacity. The methodology has been conducted by studying the effect of some operational and geometrical design parameters for the evaporator on the entire cycle exergy destruction or irreversibility, AC system coefficient of performance (COP), and total annual cost. The heat exchangers for the bus AC system are featured by a very compact frontal area due to the stringent space limitations and structure standard for the system installation. Therefore, the current study also takes in its account the effect of the variation of the design parameters on the evaporator frontal area. The irreversibility due to heat transfer across the stream-to-stream temperature difference and due to frictional pressure drops is calculated as a function of the design parameters. A cost function is introduced, defined as the sum of two contributions, the investment expense of the evaporator material and the system compressor, and the operational expense of AC system that is usually driven by an auxiliary engine or coupled with the main bus engine. The optimal trade-off between investment and operating cost is, therefore, investigated. A numerical example is discussed, in which a comparison between the commercial evaporator design and optimal design configuration has been presented in terms of the system COP and evaporator material cost. The results show that a significant improvement can be obtained for the optimal evaporator design compared with that of the commercial finned-tube evaporator that is designed based on the conventional values of the design parameters.

08/02125 Thermoelectricity analogy method for computing the periodic heat transfer in external building envelopes

Peng, C. and Wu, Z. *Applied Energy*, 2008, 85, (8), 735–754.

Simple and effective computation methods are needed to calculate energy efficiency in buildings for building thermal comfort and HVAC system simulations. This paper, which is based upon the theory of thermoelectricity analogy, develops a new harmonic method, the thermoelectricity analogy method (TEAM), to compute the periodic heat transfer in external building envelopes (EBE). It presents, in detail, the principles and specific techniques of TEAM to calculate both the decay rates and time lags of EBE. First, a set of linear equations is established using the theory of thermoelectricity analogy. Second, the temperature of each node is calculated by solving the linear equations set. Finally, decay rates and time lags are found by solving simple mathematical expressions. Comparisons show that this method is highly accurate and efficient. Moreover, relative to the existing harmonic methods, which are based on the classical control theory and the method of separation of variables, TEAM does not require complicated derivation and is amenable to hand computation and programming.

08/02126 Thermosolutal convection in saturated porous enclosure with concentrated energy and solute sources

Liu, D. *et al. Energy Conversion and Management*, 2008, 49, (1), 16–31.

Double diffusive natural convection within a vertical porous enclosure with localized heating and salting from one side is numerically studied by the finite element based finite volume method. In the formulation of the problem, use is made of the Darcy model, which allows the slip boundary condition on a solid wall to be satisfied. Comparisons with benchmark solutions for natural convection in fluid saturated porous enclosures are first presented to validate the code. Following that, an extensive series of numerical simulations is conducted in the range of $-55 \leq N \leq +55$ and $0.125 \leq L \leq 0.875$, where N and L are the buoyancy ratio and the element location, respectively. Streamlines, heatlines, masslines, isotherms and iso-concentrations in the system are produced to illustrate the flow structure transition from solutal dominated opposing to thermal dominated and solutal dominated aiding flows, respectively. The computed average Nusselt and Sherwood numbers provide guidance for locating the heating and salting element.

08/02127 Who pays for the 'beer fridge'? Evidence from Canada

Young, D. *Energy Policy*, 2008, 36, (2), 553–560.

The energy intensity of refrigerators varies widely across vintages. Recent improvements in the energy efficiency of refrigerators have the potential to decrease residential energy use, and in some locations this could have a significant impact on a typical household's greenhouse gas (GHG) emissions. Among the impediments to the realization of the energy use and environmental benefits from the technological energy-efficiency gains in Canada is the fact that a large proportion of households continue to use their old refrigerators as 'beer fridges' after the purchase of a new refrigerator. In this paper, the authors use information from the Survey of Household Energy Use (SHEU-2003) to examine this phenomenon. The empirical results are discussed in the context of existing Canadian programs that target purchases of new refrigerators and the disposal of old ones.

08/02128 Wood chip drying with an absorption heat pump

Le Lostec, B. *et al. Energy*, 2008, 33, (3), 500–512.

This paper presents the thermal and economic analysis of a mobile wood chip drying process. The dryer was subjected to different operating conditions, which were studied in order to determine the optimal characteristics of the dryer in terms of energy consumption. In addition, the impact of the exterior climatic conditions on the dryer's performance was also evaluated. The performance of the dryer coupled with an absorption heat pump was modeled in steady-state conditions under different operating parameters. Finally the system's energy performance was compared to the performance of two other systems (a wood burning furnace and a waste-heat recovery system). The results demonstrate that single-stage absorption heat pumps are only interesting when the set point temperature of the drying air is below 60 °C. Otherwise, a two-stage absorption heat pump must be used. In terms of energy and financially, this type of drying is very costly. Of the three processes that were studied, heat recovery systems proved to be the most energy efficient and economic solution.

11 ENGINES

Power generation and propulsion, electrical vehicles

08/02129 Computation of buoyancy-induced flow in a heated rotating cavity with an axial throughflow of cooling air

Tian, S. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 960–968.

In the cavity between the co-rotating compressor discs in gas turbine engines, the flow is very complex because of the multiple driving forces including the centrifugal buoyancy force, the Coriolis force and the inertial force. Numerical analysis was carried out in a simple rotating cavity with cooling air axial throughflow and a heated shroud. Efforts were focused upon the flow structure and its variations. The results reveal the non-axisymmetrical flow structures with cyclonic and anti-cyclonic circulations, which slip relative to the rotating cavity in the opposite direction (that is, rotate with a slower speed than the cavity) and the patterns remain unchanged. These structures are not unique, and four types with one, two, three, four pairs of circulations are obtained. For any particular set of conditions, the final structure can depend on the path taken: as axial Reynolds number is increased the number of circulation couples increases, and as Grashof number is increased the number of circulation couples decreases. At high Grashof number, the variation of Nu_{av} with Gr is consistent with the Rayleigh–Bénard convection.

08/02130 Design criteria for modified Zeta rectifier with reduced voltage stress and low effect on main

Sabzali, A. J. *et al. Energy Conversion and Management*, 2008, 49, (2), 157–168.

A single switch low harmonic rectifier based on the Zeta converter, also known as dual of single ended primary inductance converter (dual SEPIC), is presented in this paper. By adding an extra diode in series with both inductors, new discontinuous current modes (DCM) are obtained. By selecting the right DCM, it is possible to design the rectifier such that the voltage on the intermediate dc-link capacitor is less than the output DC voltage. This will result in reduced voltage stress on the main power switch, as well as zero current switching at turn on. The operating principles are confirmed with computer simulation and experimental results.

08/02131 Design of a heat exchanger to reduce the exhaust temperature in a spark-ignition engine

Lee, S. and Bae, C. *International Journal of Thermal Sciences*, 2008, 47, (4), 468–478.

A design of experiments (DOE) technique was used to design an exhaust heat exchanger to reduce the exhaust gas temperature under high load conditions in a spark-ignition engine. Through a limited number of experiments, the DOE evaluated the influence and the interaction of eight selected design parameters of the heat exchanger that affect the cooling performance of the exhaust gas. The heat exchanger was installed between the exhaust manifold and the inlet of the close-coupled catalytic converter to avoid thermal aging. To maximize the heat transfer between the exhaust gas and coolant, fins were implemented at the inner surface of the heat exchanger. The design parameters consisted of the fin geometry (i.e. length, thickness, arrangement, and number of fins), coolant direction, exchanger wall thickness, and the length of the heat exchanger. The DOE results were analysed and the acceptable range of each design parameter is discussed.

08/02132 Diagnosis of voltage collapse due to induction motor stalling using static analysis

Karbalaei, F. *et al. Energy Conversion and Management*, 2008, 49, (2), 151–156.

Induction motor stalling is one of the important reasons for voltage collapse. This paper presents that, for induction motor stalling diagnosis, it is not necessary to use a third- or first-order dynamic model of induction motors. Instead, a method is presented based on algebraic calculations for which the steady state model of the induction motor considering different kinds of mechanical loads (constant and variable torque) is added to the power flow equations. Simulation results for a simple system confirm the correctness of the proposed method as compared to dynamic simulation results.

08/02133 Diesel/biodiesel proportion for by-compression ignition engines

Morón-Villarreyes, J. A. *et al. Fuel*, 2007, 86, (12–13), 1977–1982.

Nowadays, computational combustion (CC) presents complex mathematical models where the fuel physical properties are important parameters. Most research on biodiesel aims at reducing pollutant emissions placing little emphasis on the relation between the fuel physical properties and its internal combustion. In this work it is presented a brief review on the importance of the physical properties and their relation to the internal combustion proposing a method to determine the volumetric proportion of biodiesel, which will have efficient combustion in compression engines. The main injection and atomization properties related to the quality of ignition were measured, such as: density, viscosity and surface tension for mineral diesel (B0), biodiesel (B100) and other eleven mixtures BXX. With the proposed method, it was found that mixtures of diesel/soybean ethylic biodiesel from B2 to B30, present satisfactory internal combustion. The method may be used to predict the behaviour of BXX proportions from other animal or vegetable sources and even be used as a preliminary or complementary criterion for the biodiesel certification.

08/02134 Energy consideration for designing supercharged ram jet engines

Al-Qutub, A. M. *International Journal of Energy Research*, 2008, 32, (2), 107–115.

The present work investigates the energy considerations and performance characteristics of a newly proposed supercharged ram jet engine. Thermodynamics and fluid mechanics analyses were developed to predict specific thrust, thrust-specific fuel consumption (TSFC), overall efficiency, and thrust-to-weight ratio of the engine. Compressor pressure ratio and efficiency, combustor temperature, and pressure losses in the burner and nozzle are considered as primary variables in the engine performance analysis. Performance characteristics are calculated to illustrate the effect of each parameter independently at different flight speeds. This is done while maintaining other parameters at given typical operating values. A computer program was developed to perform the iterative calculations. Results indicate that the compressor pressure ratio and the combustion product temperature are the most critical parameters in determining the performance of the engine. At compressor pressure ratio of 1.15–1.2, the typical static thrust-to-weight ratio is at maximum. Increasing combustion product temperature increases the thrust-to-weight ratio as well as TSFC. Finally, newly developed high power-to-weight ratio IC engine makes it possible for the supercharged ram jet engine to achieve high performance, in terms of thrust-to-weight ratio and TSFC.

08/02135 Experiments and modelling of surge in small centrifugal compressor for automotive engines

Galindo, J. *et al. Experimental Thermal and Fluid Science*, 2008, 32, (3), 818–826.

In this paper the surge phenomenon in small centrifugal compressors used for turbocharging internal combustion engines is analysed. The experimental work was focused on the measurement of compressor behaviour within the surge zone by means of a specifically designed facility. The presented model is based on the introduction of a fluid inertia term that accounts for the non quasi steady effects and the use of a compressor map extended to the surge and negative flows zone obtained from experimental tests. The compressor model was implemented in a one-dimensional gas-dynamic model. The comparison of the modelled and measured evolution of instantaneous pressure during deep surge operation shows good agreement. Furthermore, the model is also able to predict the amplitude and frequency of pressure pulses when the compressor operates in surge with different outlet duct lengths.

08/02136 Finite-time thermodynamic modelling and analysis of an irreversible Otto-cycle

Ge, Y. *et al. Applied Energy*, 2008, 85, (7), 618–624.

The performance of an air standard Otto-cycle is analysed using finite-time thermodynamics. In the irreversible cycle model, the non-linear relation between the specific heat of the working fluid and its temperature, the friction loss computed according to the mean velocity of the piston, the internal irreversibility described by using the compression and expansion efficiencies, and the heat-transfer loss are considered. The relations between the power output and the compression ratio, between the thermal efficiency and the compression ratio, as well as the optimal relation between the power output and the efficiency of the cycle are indicated by numerical examples. Moreover, the effects of internal irreversibility, heat-transfer loss and friction loss on the cycle performance are analysed. The results obtained in this paper may provide guidance for the design of practical internal-combustion engines.

08/02137 Fuel economy and torque tracking in camless engines through optimization of neural networks

Ashhab, M. S. S. *Energy Conversion and Management*, 2008, 49, (2), 365–372.

The feed forward controller of a camless internal combustion engine is modelled by inverting a multi-input multi-output feed forward artificial neural network (ANN) model of the engine. The engine outputs, pumping loss and cylinder air charge, are related to the inputs, intake valve lift and closing timing, by the artificial neural network model, which is trained with historical input–output data. The controller selects the intake valve lift and closing timing that will mimimize the pumping loss and achieve engine torque tracking. Lower pumping loss means better fuel economy, whereas engine torque tracking gurantees the driver's torque demand. The inversion of the ANN is performed with the complex method constrained optimization. How the camless engine inverse controller can be augmented with adaptive techniques to maintain accuracy even when the engine parts degrade is discussed. The simulation results demonstrate the effectiveness of the developed camless engine controller.

08/02138 LPG fueled diesel engine using diethyl ether with exhaust gas recirculation

Jothi, N. K. M. *et al. International Journal of Thermal Sciences*, 2008, 47, (4), 450–457.

The present investigation was to study the effect of exhaust gas recirculation (EGR) on homogeneous charge ignition engine. A stationary four stroke, single cylinder, direct injection diesel engine capable of developing 3.7 kW at 1500 rpm was modified to operate in HCCI mode. In the present work the diesel engine was operated on 100% liquified petroleum gas (LPG). The LPG has a low cetane number (<3), therefore diethyl ether (DEE) was added to the LPG for ignition purpose. DEE is an excellent ignition enhancer (cetane number >125) and has a low auto ignition temperature (160 °C). Experimental results showed that by EGR technique, at part loads the brake thermal efficiency increases by about 2.5% and at full load, NO concentration could be considerably reduced to about 68% as compared to LPG operation without EGR. However, higher EGR percentage affects the combustion rate and significant reduction in peak pressure at maximum load.

08/02139 Natural convection flows in a trapezoidal enclosure with uniform and non-uniform heating of bottom wall

Natarajan, E. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 747–756.

A penalty finite element analysis with bi-quadratic elements is performed to investigate the influence of uniform and non-uniform heating of bottom wall on natural convection flows in a trapezoidal cavity. In the present investigation, bottom wall is uniformly and non-uniformly heated while two vertical walls are maintained at constant cold temperature and the top wall is well insulated. Parametric study for the wide range of Rayleigh numbers (Ra), $10^3 \geq Ra \geq 10^5$ and Prandtl numbers (Pr), $0.07 \geq Pr \geq 100$ shows consistent performance of the present numerical approach to obtain the solutions in terms of stream functions and the temperature profiles. For certain values of the parameters studied in the above range, a symmetry is observed while representing the flow patterns in terms of stream functions. Non-uniform heating of the bottom wall produces greater heat transfer rate at the centre of the bottom wall than uniform heating case for all Rayleigh numbers but average Nusselt number shows overall lower heat transfer rate for non-uniform heating case. The power law correlations between average Nusselt number and Rayleigh numbers are presented. The effect of Prandtl number in the variation of local and average Nusselt numbers is more significant for Prandtl numbers in the range 0.07–0.7 than 10–100.

08/02140 The effects of fuel characteristics and engine operating conditions on the elemental composition of emissions from heavy duty diesel buses

Lim, M. C. H. *et al. Fuel*, 2007, 86, (12–13), 1831–1839.

The effects of fuel characteristics and engine operating conditions on elemental composition of emissions from 12 heavy-duty diesel buses have been investigated. Two types of diesel fuels: low sulfur diesel (LSD) and ultra low sulfur diesel (ULSD) fuels with 500 ppm and 50 ppm sulfur contents, respectively, and three driving modes corresponding to 25%, 50% and 100% power were used. Elements present in the tailpipe emissions were quantified by inductively coupled plasma mass spectrometry (ICPMS) and those found in measurable quantities included Mg, Ca, Cr, Fe, Cu, Zn, Ti, Ni, Pb, Be, P, Se, Ti and Ge. Multivariate analyses using multi-criteria decision making methods (MCDM), principal component analysis (PCA) and partial least squares (PLS) facilitated the extraction of information about the structure of the data. MCDM showed that the emissions of the elements were strongly influenced by the engine driving conditions while the PCA loadings plots showed that the emission factors of the elements were correlated with those of other pollutants such as particle number, total suspended particles, CO, CO_2 and NO_x. Partial least square analysis revealed that the emission factors of the elements were strongly dependent on the fuel parameters such as the fuel sulfur content, fuel density, distillation point and cetane index. Strong correlations were also observed between these pollutants and the engine power or exhaust temperature. The study provides insights into the possible role of fuel sulfur content in the emission of inorganic elements from heavy duty diesel vehicles.

08/02141 Theoretical investigation of effects of light fuel fumigation on diesel engine performance and emissions

Şahin, Z. and Durgun, O. *Energy Conversion and Management*, 2007, 48, (7), 1952–1964.

In the presented study, the effects of light fuel fumigation on the diesel engine cycle and characteristics have been examined theoretically. For this purpose, a computer program has been developed for prediction of the diesel engine cycle and engine characteristics in the cases of neat diesel fuel (NDF) and light fuel (LF) fumigation. Here, ethanol is used as the fumigating (supplementary) light fuel. For calculation of the diesel engine cycle, the quasi-dimensional phenomenological combustion model developed by Shahed and then Ottikkutti has been used and developed with new assumptions. Firstly, the accuracy of the developed engine cycle model for NDF and LF fumigation has been controlled by using various experimental and theoretical results. Then, the effects of 2.5–20% ethanol fumigation have been investigated at variable equivalence ratios (VER) and constant equivalence ratios (CER). It can be said that for increasing ethanol fumigation at VER, the effective power, effective efficiency and carbon monoxide (CO) ratios increase and the specific fuel consumption (SFC) and nitric oxide (NO) concentration decrease. Effective power, effective efficiency and NO concentration increase, generally, with increasing ethanol fumigation ratios at CER. In this case, SFC and CO ratio exhibits an incremental tendency generally.

08/02142 Thermal fatigue on pistons induced by shaped high power laser. Part I: experimental study of transient temperature field and temperature oscillation

Song, H. W. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 757–767.

Thermal fatigue behaviour is one of the foremost considerations in the design and operation of diesel engines. It is found that thermal fatigue is closely related to the temperature field and temperature fluctuation in the structure. In this paper, spatially shaped high power laser was introduced to simulate thermal loadings on the piston. The incident Gaussian beam was transformed into concentric multi-circular beam of specific intensity distribution with the help of diffractive optical element, and the transient temperature fields in the piston similar to those under working conditions could be achieved by setting up appropriate loading cycles. Simulation tests for typical thermal loading conditions, i.e. thermal high cycle fatigue and thermal shock (or thermal low cycle fatigue) were carried out. Several important parameters that affect the transient temperature fields and/or temperature oscillations, including controlling mode, intensity distribution of shaped laser, laser power, temporal profile of laser pulse, heating time and cooling time in one thermal cycle, etc., were investigated and discussed. The results show that as a novel method, the shaped high power laser can simulate thermal loadings on pistons efficiently, and it is helpful in the study of thermal fatigue behaviour in pistons.

Hybrid engine systems

08/02143 Performance and exhaust emissions in the use of biodiesel in outboard diesel engines

Murillo, S. *et al. Fuel*, 2007, 86, (12–13), 1765–1771.

The objective of this study is to compare the engine performance and emission results of biodiesel derived from used cooking oil when applied in different proportions in outboard engines. Results revealed that the use of biodiesel resulted in lower emissions of CO (up to 12%) with an increase in emissions of NO_x (up to 20%, except in one case which presented a slight reduction). Biodiesel also presented a slight increase in specific fuel consumption (lower than 11.4%) which may be acceptable considering the reduction in exhaust emissions. The experimental results proved that biodiesel alone or blended biodiesel can be used in compression ignition outboard engines, thereby providing a viable alternative to diesel. Special attention should be paid to the use of biodiesel in boats operating on lakes and rivers and in sheltered bays, which are more vulnerable to pollution.

08/02144 Performance of a DI diesel engine fuelled by blends of diesel and kiln-produced pyroligneous tar

Honnery, D. *et al. Biomass and Bioenergy*, 2008, 32, (4), 358–365.

This paper presents results of experiments undertaken to determine the performance of a direct injection (DI) diesel engine fuelled by blends of kiln-produced pyroligneous tar (PT) and diesel. The PT was sourced from Bulgaria where it was produced from a pine feedstock via a traditional kiln method that involves separation of the aqueous pyroligneous acid fraction. The tar is characterized by high carbon concentration, viscosity and high heating value. Although high, at fuel injection temperatures over 120 °C the tar's viscosity is likely to be lower than diesel. Analysis by GC revealed a number of compounds typically extracted from wood-based tar products. Blends containing 20% and 40% PT with diesel were tested in a four-cylinder, four-stoke DI diesel engine. The blends are stable and readily formed. Little difference in engine performance relative to diesel was found for 20% PT blends. PT blends (40%) exhibit significantly higher in-cylinder gas temperature and pressure. Ignition delay for both blends is longer than diesel, as is the fuel burn rate during the premixed stage of the combustion. During the diffusion stage of combustion, the fuel burn rate is lower relative to diesel. The performance of engines fuelled by blends containing 40% or more PT could be improved through optimization of engine systems.

08/02145 Static and dynamic wind turbine simulator using a converter controlled dc motor

Monfared, M. *et al. Renewable Energy*, 2008, 33, (5), 906–913.

This paper describes a new wind turbine simulator for dynamic conditions. The authors have developed an experimental platform to simulate the static and dynamic characteristics of real wind energy conversion system. This system consists of a 3 kW dc motor, which drives a synchronous generator. The converter is a 3 kW single-phase half-controlled converter. MATLAB/Simulink real time control software interfaced to I/O board and a converter controlled dc motor are used instead of a real wind turbine. A MATLAB/Simulink model is developed that obtains wind profiles and, by applying real wind turbine characteristics in dynamics and rotational speed of dc motor, calculates the command shaft torque of a real wind turbine. Based on the comparison between calculated torques with command one, the shaft torque of dc motor is regulated accordingly by controlling armature current demand of a single-phase half-controlled ac–dc converter. Simulation and experimental results confirm the effectiveness of proposed wind turbine simulator in emulating and therefore evaluating various turbines under a wide variety of wind conditions.

08/02146 Synergistic integration of a gas turbine and solid oxide fuel cell for improved transient capability

Mueller, F. *et al. Journal of Power Sources*, 2008, 176, (1), 229–239.

A theoretical solid oxide fuel cell–gas turbine hybrid system has been designed using a Capstone 60 kW micro-gas turbine. Through simulation it is demonstrated that the hybrid system can be controlled to achieve transient capability greater than the Capstone 60 kW recuperated gas turbine alone. The Capstone 60 kW gas turbine transient capability is limited because in order to maintain combustor, turbine and heat exchangers temperatures within operating requirements, the Capstone combustor fuel-to-air ratio must be maintained. Potentially fast fuel flow rate changes, must be limited to the slower, inertia limited, turbo machinery air response. This limits a 60 kW recuperated gas turbine to transient response rates of approximately $1\,\mathrm{kW\,s^{-1}}$. However, in the SOFC/GT hybrid system, the combustor temperature can be controlled, by manipulating the fuel cell current, to regulate the amount of fuel sent to the combustor. By using such control pairing, the fuel flow rate does not have to be constrained by the air flow in SOFC/GT hybrid systems. This makes it possible to use the rotational inertia of the gas turbine, to buffer the fuel cell power response, during fuel cell fuel flow transients that otherwise limit fuel cell system transient capability. Such synergistic integration improves the transient response capability of the integrated SOFC gas turbine hybrid system. Through simulation it has been demonstrated that SOFC/GT hybrid system can be developed to have excellent transient capability.

Transport battery development

08/02147 A micro-solid oxide fuel cell system as battery replacement

Bieberle-Hütter, A. *et al. Journal of Power Sources*, 2008, 177, (1), 123–130.

The concept and the design of a micro-solid oxide fuel cell system is described and discussed. The system in this study is called the ONEBAT system and consists of the fuel cell PEN (positive electrode – electrolyte – negative electrode) element, a gas processing unit, and a thermal system. PEN elements of free-standing multi-layer membranes are fabricated on Foturan® and on Si substrates using thin film deposition and microfabrication techniques. Open circuit voltages of up to 1.06 V and power of $150\,\mathrm{mW\,cm^{-2}}$ are achieved at 550 °C. The membranes are stable up to 600 °C. The gas processing unit allows butane conversion of 95% and hydrogen selectivity of 83% at 550 °C in the reformer and efficient after-burning of hydrogen, carbon monoxide, and lower hydrocarbons in the post-combustor. Thermal system simulations prove that a large thermal gradient of more than 500 °C between the hot module and its exterior are feasible. The correlation between electrical power output – system size and thermal conductivity – heat-transfer coefficient of the thermal insulation material are shown. The system design studies show that the single sub-systems can be integrated into a complete system and that the requirements for portable electronic devices can be achieved with a base unit of 2.5 W and a modular approach.

08/02148 Low cost RISC implementation of intelligent ultra fast charger for Ni–Cd battery

Petchjatuporn, P. *et al. Energy Conversion and Management*, 2008, 49, (2), 185–192.

This paper presents a low-cost reduced instruction set computer (RISC) implementation of an intelligent ultra fast charger for a nickel–cadmium (Ni–Cd) battery. The charger employs a genetic algorithm (GA) trained generalized regression neural network (GRNN) as a key to ultra fast charging while avoiding battery damage. The tradeoff between mean square error (MSE) and the computational burden of the GRNN is addressed. Besides, an efficient technique is proposed for estimation of a radial basis function (RBF) in the GRNN. Hardware realization based upon the techniques is discussed. Experimental results with commercial Ni–Cd batteries reveal that while the proposed charger significantly reduces the charging time, it scarcely deteriorates the battery energy storage capability when compared with the conventional charger.

08/02149 Predicting state of charge of lead-acid batteries for hybrid electric vehicles by extended Kalman filter

Vasebi, A. *et al. Energy Conversion and Management*, 2008, 49, (1), 75–82.

This paper describes and introduces a new non-linear predictor and a novel battery model for estimating the state of charge (SoC) of lead-acid batteries for hybrid electric vehicles (HEV). Many problems occur for a traditional SoC indicator, such as offset, drift and long-term state divergence, therefore this paper proposes a technique based on the extended Kalman filter (EKF) in order to overcome these problems. The underlying dynamic behaviour of each cell is modelled using two capacitors (bulk and surface) and three resistors (terminal, surface and end). The SoC is determined from the voltage present on the bulk capacitor. In this new model, the value of the surface capacitor is constant, whereas the value of the bulk capacitor is not. Although the structure of the model, with two constant capacitors, has been previously reported for lithium-ion cells, this model can also be valid and reliable for lead-acid cells when used in conjunction with an EKF to estimate SoC (with a little variation). Measurements using real-time road data are used to compare the performance of conventional internal resistance (R_{int}) based methods for estimating SoC with those predicted from the proposed state estimation schemes. The results show that the proposed method is superior to the more traditional techniques, with accuracy in estimating the SoC within 3%.

08/02150 Separator profile selection for optimal battery performance

Whear, J. K. *Journal of Power Sources*, 2008, 177, (1), 226–230.

Battery performance, depending on the application, is normally defined by power delivery, electrical capacity, cycling regime and life in service. In order to meet the various performance goals, the Battery Design Engineer can vary things such as grid alloys, paste formulations, number of plates and methods of construction. Another design option available to optimize the battery performance is the separator profile. The goal of this paper is to demonstrate how separator profile selection can be utilized to optimize battery performance and manufacturing efficiencies. Also time will be given to explore novel separator profiles which may bring even greater benefits in the future. All major lead-acid application will be considered including automotive, motive power and stationary.

08/02151 Simulation of the market penetration of hydrogen fuel cell vehicles in Korea

Jun, E. *et al. International Journal of Energy Research*, 2008, 32, (4), 318–327.

As fuel cell technologies develop, hydrogen-powered vehicles are becoming more interesting. This paper studied the hydrogen economy, and particularly the use of hydrogen-powered vehicles in Korea. Vensim, a system dynamic code, was used to simulate the dynamics in the transportation market, assuming various types of vehicles such as gasoline, hybrid electricity, and hydrogen powered. Market share for each vehicle was predicted using currently available data. The results indicated that the hydrogen era may not be as bright as was thought, the main barrier being fuel cell cost. Thus, in order to expand the fuel cell vehicles (FCVs) market, hydrogen fuel cell cost needs to be dramatically reduced. Hydrogen-powered FCV cost, including operating and capital costs, should reach $0.16 per kilometre in order to seize 50% of the newly created transportation market. However, if strong policies or subsidies are implemented, the results predicted here will be affected.

12 REFRACTORIES/ CERAMICS

Properties, production, applications

08/02152 Energy and material flow analysis: application to the storage stage of clay in the roof-tile manufacture

Torres, M. T. *et al. Energy*, 2008, 33, (6), 963–973.

Energy and material flow analysis (EMFA) comprises a whole family of tools to optimize the consumption of energy, raw material, water and the discharge of effluents by pursuing systematically internal flows of energy and mass in production processes. Computer software with various degrees of complexity are available to facilitate this analysis. In this paper, EMFA is applied to the case of the manufacture of roof tiles in a ceramic industry. The stage under evaluation is the storage of clay. A computational tool, Umberto, was used for the analysis. This software allows visualizing the process, units and flows, to analyse from an environmental point of view the effluents and the costs involved as well as to carry out both the mass and energy balances. As the main objective of this study is to implement an EMFA tool into the system, so that it can operate more efficiently and reduce its environmental impact, the evaluation of flows and stocks was made using the performance indicators provided by Umberto. The iterative capability of the software allows the identification of improvement potential, by a quantitative comparison of input and output data with target values.

08/02153 Recycling crushed glass in concrete mixes

Alhumoud, J. M. *et al. International Journal of Environment and Waste Management*, 2008, 2, (1–2), 111–124.

A strategy using recycled glass as aggregate replacement in concrete is presented in this paper. The properties of fresh and hardened concrete made with fine and coarse crushed glass are presented and discussed. Proportions of 0–100% of crushed glass are implemented in the concrete specimen and the compressive strength up to 700°C is measured. The results indicated that the use of crushed glass in concrete is a viable and effective recycling option, in particular when used in proportions of between 10% and 25% where the compressive strength exhibited higher values than those of normal concrete at ambient and elevated temperatures.

13 ALTERNATIVE ENERGY SUPPLIES

Biofuels and bioconversion energy

08/02154 A technical and environmental analysis of co-combustion of coal and biomass in fluidised bed technologies

McIlveen-Wright, D. R. *et al. Fuel*, 2007, 86, (14), 2032–2042.

The use of biomass, which is considered to produce no net CO_2 emissions in its life cycle, can reduce the effective CO_2 emissions of a coal-fired power generation system, when co-fired with the coal, but may also reduce system efficiency. The technical and environmental analysis of fluidized bed technologies, using the ECLIPSE suite of process simulation software, is the subject of this study. System efficiencies for generating electricity are evaluated and compared for the different technologies and system scales. Several technologies could be applied to the co-combustion of biomass or waste and coal. The assessment studies here examine the potential for co-combustion of (a) a 600 MWe pulverized fuel (PF) power plant (as a reference system), (i) co-firing coal with straw and sewage sludge and (ii) using straw derived fuel gas as return fuel; (b) a 350 MWe pressurized fluidized bed combustion (PFBC) system co-firing coal with sewage sludge; (c) 250 MWe and 125 MWe circulating fluidized bed combustion (CFBC) plants co-firing coal with straw and sewage sludge; (d) 25 MWe CFBC systems co-firing low and high sulfur content coal with straw, wood and woody matter pressed from olive stones (WPOS); (e) 12 MWe CFBC co-firing low and high sulfur content coal with straw or wood; and (f) 12 MWe bubbling fluidized bed combustion (BFBC), also co-firing low and high sulfur content coal with straw or wood. In the large systems the use of both straw and sewage sludge resulted in a small reduction in efficiency (compared with systems using only coal as fuel). In the small-scale systems the high moisture content of the wood chips chosen caused a significant efficiency reduction. Net CO_2 emissions are reduced when biomass is used, and these are compared for the different types and scales of fluidized bed technologies. NO_x emissions were affected by a number of factors, such as bed temperature, amount of sorbent used for SO_2 capture and HCl emitted.

08/02155 Bark content estimation in poplar (*Populus deltoides* L.) short-rotation coppice in Central Italy

Guidi, W. *et al. Biomass and Bioenergy*, 2008, 32, (6), 518–524.

Differences in bark and wood content in woody biomass directly affect its quality and economic value as an energy source. In order to estimate the quality of biomass before harvesting, an allometric regression of bark percentage of total aboveground biomass and DHB (diameter at 1.30 m height) was developed in a 2-year poplar short-rotation coppice system in central Italy. Firstly, a relationship between mean diameter and bark content percentage was established in 1 cm-wide sections belonging to all diametric classes. The model of best fit for these stem cylindrical sections was an equation $y = ax^{-b}$. Following this, sample stems (of which the authors measured DHB) were collected and divided into sections belonging to a diameter class. Fresh and dry matter were determined for each class. Using the first equation, bark content was calculated separately for all classes. Thereafter, a second equation between bark content in the whole stem and DHB was developed. The best fitting equation for the whole stem was $y = cx^{-d}$. Bark content in the whole stem ranged from 33.9–31.4% in large-sized DHB stems to 15.1–12.5% in smallest stems, depending on their moisture content. Bark content decreased rapidly in the small diametric classes until DHB reached 4 cm. Thereafter, the ratio of reduction of bark percentage dropped.

08/02156 Can wood quality justify local preferences for firewood in an area of caatinga (dryland) vegetation?

Ramos, M. A. *et al. Biomass and Bioenergy*, 2008, 32, (6), 503–509.
Studies have been undertaken in many parts of the world to evaluate the qualities of fuelwood, but rarely is this information associated with an examination of the preferences of the local populations. As such, the present study sought to address the question of whether local preferences for fuelwoods can be explained by the physical characteristics of the wood itself. To that end, the residents of 102 domiciles in a rural community in NE Brazil were interviewed and a list was compiled of all the plants used and preferred for domestic use. These woods were subsequently analysed to determine their density, water content, and fuel value index (FVI). Although a total of 67 species were identified by the residents, only 14 were described as being preferred – due to their great number of desirable attributes for cooking. The density, humidity, and FVI of 38 species used and/or preferred were determined. A significant relationship ($p < 0.05$) was noted between plants with the highest FVIs and the most preferred fuelwood plants in the region, indicating that local preference could be explained by the physical properties that were examined.

08/02157 Carbon-negative biofuels

Mathews, J. A. *Energy Policy*, 2008, 36, (3), 940–945.
Current Kyoto-based approaches to reducing the Earth's greenhouse gas problem involve looking for ways to reduce emissions. But these are palliative at best, and at worst will allow the problem to get out of hand. It is only through sequestration of atmospheric carbon that the problem can be solved. Carbon-negative biofuels represent the first potentially huge assault on the problem, in ways that are already technically feasible and practicable. The key to carbon negativity is to see it not as technically determined but as an issue of strategic choice, whereby farmers and fuel producers can decide how much carbon to return to the soil. Biochar amendment to the soil not only sequesters carbon but also enhances the fertility and vitality of the soil. The time is approaching when biofuels will be carbon negative by definition, and, as such, they will sweep away existing debates over their contribution to the solution of global warming.

08/02158 Characteristics of hemicellulose, cellulose and lignin pyrolysis

Yang, H. *et al. Fuel*, 2007, 86, (12–13), 1781–1788.
The pyrolysis characteristics of three main components (hemicellulose, cellulose and lignin) of biomass were investigated using, respectively, a thermogravimetric analyser (TGA) with differential scanning calorimetry (DSC) detector and a pack bed. The releasing of main gas products from biomass pyrolysis in TGA was on-line measured using Fourier transform infrared (FTIR) spectroscopy. In thermal analysis, the pyrolysis of hemicellulose and cellulose occurred quickly, with the weight loss of hemicellulose mainly happened at 220–315 °C and that of cellulose at 315–400 °C. However, lignin was more difficult to decompose, as its weight loss happened in a wide temperature range (from 160 to 900 °C) and the generated solid residue was very high (40 wt.%). From the viewpoint of energy consumption in the course of pyrolysis, cellulose behaved differently from hemicellulose and lignin; the pyrolysis of the former was endothermic while that of the latter was exothermic. The main gas products from pyrolysing the three components were similar, including CO_2, CO, CH_4 and some organics. The releasing behaviours of H_2 and the total gas yield were measured using Micro-GC when pyrolysing the three components in a packed bed. It was observed that hemicellulose had higher CO_2 yield, cellulose generated higher CO yield, and lignin owned higher H_2 and CH_4 yield. A better understanding to the gas products releasing from biomass pyrolysis could be achieved based on this in-depth investigation on three main biomass components.

08/02159 Characterization of biomass energy projects in Southeast Asia

Carlos, R. M. and Khang, D. B. *Biomass and Bioenergy*, 2008, 32, (6), 525–532.
Southeast Asian countries have the potential to implement a substantial number of biomass energy plants using agro-industrial residues as feedstock. However, this potential is largely untapped. This paper investigates the key characteristics of biomass industry in the region: application, size of the projects, fuel resources, ownership and project structure, financing and the connections to the national power grids based on the analysis 165 biomass energy projects at various stages of implementation in Southeast Asia. Two critical factors are identified that shaped the development and implementation of biomass energy projects in Southeast Asia: the availability of biomass fuel and the regulatory framework and environment. The results highlight the potentials and opportunities as well as point to the direction for development of biomass energy projects in the region.

08/02160 Climate classification and passive solar design implications in China

Lau, C. C. S. *et al. Energy Conversion and Management*, 2007, 48, (7), 2006–2015.
China's climate differs greatly in various regions, ranging from severe cold to hot and arid to humid. This has significant influences on energy efficient building design strategies and energy use. Solar radiation data from 123 measuring stations were used to propose a map indicating the solar radiation climates in China. A cluster analysis was adopted to identify the prevailing solar climates using the monthly average daily clearness index, K_t, as climatic variable. Five major solar climates were identified with annual average K_t ranging from 0.3 in the Sichuan Basin to 0.65 in the north and northwest regions. The solar climates were compared with the more widely used general (thermal) climates (severe cold, cold, hot summer and cold winter, mild and hot summer and warm winter) and the major topography (basin, plain and plateau), and implications for building designs were briefly discussed.

08/02161 Comparison of methodologies for TMY generation using 10 years data for Damascus, Syria

Skeiker, K. *Energy Conversion and Management*, 2007, 48, (7), 2090–2102.
The generation of a typical meteorological year (TMY) is of great importance for calculations concerning many applications in the field of thermal engineering. The need of an accurate TMY for simulations has been well recognized over the years. Various methods for deriving TMYs have been developed, but their final results can be significantly different. In this paper, the major methodologies reported in the literature were applied to 10-year hourly measurements of weather data from Damascus, Syria. The TMYs obtained were evaluated according to their impact on the typical Syrian building's thermal system in order to decide which method should be recommended for generating typical meteorological years and for predicting the performance of thermal systems in buildings. Based on simulation results for seasonally, monthly and daily building thermal loads, three widely used statistical estimators, namely, root mean square difference RMSD, total standard error SEE and χ^2 were calculated to assess the performance of each TMY. The findings showed that the TMY giving the closest performance to the average performance of the building's thermal system as predicted using the 10-year weather data is the one generated by using the modified Sandia method. This method gives sufficiently accurate results compared with the other methods reported in the literature.

08/02162 Comparison of transesterification methods for production of biodiesel from vegetable oils and fats

Demirbas, A. *Energy Conversion and Management*, 2008, 49, (1), 125–130.
Comparative studies on transesterification methods were presented in this work. Biodiesel is obtained from a chemical reaction called transesterification (ester exchange). The reaction converts esters from long chain fatty acids into mono alkyl esters. Chemically, biodiesel commonly is a fatty acid methyl ester. Vegetable oils can be transesterified by heating them with a large excess of anhydrous methanol and an acidic or basic reagent as catalyst. A catalyst is usually used to improve the reaction rate and yield. In a transesterification reaction, a larger amount of methanol was used to shift the reaction equilibrium to the right side and produce more methyl esters as the proposed product. Several aspects including the type of catalyst (alkaline, acid or enzyme), alcohol/vegetable oil molar ratio, temperature, purity of the reactants (mainly water content) and free fatty acid content have an influence on the course of the transesterification. A non-catalytic biodiesel production route with supercritical methanol has been developed that allows a simple process and high yield because of the simultaneous transesterification of triglycerides and methyl esterification of fatty acids. In the catalytic supercritical methanol transesterification method, the yield of conversion rises to 60–90% for the first 1 min.

08/02163 Cotton logistics as a model for a biomass transportation system

Ravula, P. P. *et al. Biomass and Bioenergy*, 2008, 32, (4), 314–325.
To reach the US Department of Energy's goal of replacing 30% of current petroleum consumption by biomass and its products by year 2030, various systems capable of harvesting, storing and transporting

biomass efficiently, at a low cost, need to be designed. The transportation system of a cotton gin, which shares several key components with a biomass transportation system, was simulated using a discrete event simulation procedure, to determine the operating parameters under various management practices. The cotton module transportation system, when operating under a FIFO management plan, was found to operate at 77% utilization factor, while the actual ginning process operated at 69%. Two greedy algorithm-based management policies were simulated, which increased the gin operational factor to 100%, but doing so required an increase in gin inventory level. A knapsack model, with travel times, was constructed and solved to obtain the lower bound for the transportation system. The significance of these operating parameters and their links to a biomass transportation system are presented. Using the new management strategies, the utilization factor for the transportation system was increased to 99%. To achieve this improvement, the transportation manager must know where all modules are located and have the ability to dispatch a hauler to any location.

08/02164 Easy assessment of diversity in *Jatropha curcas* L. plants using two single-primer amplification reaction (SPAR) methods

Ranade, S. A. *et al. Biomass and Bioenergy*, 2008, 32, (6), 533–540.

Jatropha curcas L. (physic nut) has drawn attention in recent years as a source of seed oil that can provide an economically viable substitute for diesel. Very little work on provenance trials and genetic resources of *J. curcas* L. has been reported so far. Though *J. curcas* grows widely in India and several collections of the plant are also maintained, pedigree and provenance records are not always available. This article reports the studies on the diversity amongst the accessions of *J. curcas* L., both amongst already held collections as well as from a few locations in the wild. Two single-primer amplification reaction (SPAR) methods were used for this purpose. The accessions from the North East were most distant from all other accessions in UPGMA analysis. The NBRI, Bhubaneshwar and Lalkuan accessions were more related to each other. The UPGMA tree clearly shows well-separated accession groups: NBRI, Bhubaneshwar, North East, Lalkuan and Outgroup. The study suggests that this relatively recently introduced plant species shows adequate genetic diversity in India and that the SPAR methods are useful for a rapid assessment of the same. The methods provide important tools for analysing the diversity within the available collections to shortlist the parental lines for adaptability trials and further improvement of *Jatropha* plants.

08/02165 Evaluation of marine algae as a source of biogas in a two-stage anaerobic reactor system

Vergara-Fernéndez, A. *et al. Biomass and Bioenergy*, 2008, 32, (4), 338–344.

The marine algae are considered an important biomass source; however, their utilization as energy source is still low around the world. The technical feasibility of marine algae utilization as a source of renewable energy was studied to laboratory scale. The anaerobic digestion of *Macrocystis pyrifera*, *Durvillea antarctica* and their blend 1:1 (w/w) was evaluated in a two-phase anaerobic digestion system, which consisted of an anaerobic sequencing batch reactor and an upflow anaerobic filter (UAF). The results show that 70% of the total biogas produced in the system was generated in the UAF, and both algae species have similar biogas productions of $180.4(\pm 1.5)\,\mathrm{mL\,g^{-1}}$ dry algae $\mathrm{d^{-1}}$, with a methane concentration around 65%. The same methane content was observed in biogas yield of algae blend; however, a lower biogas yield was obtained. In conclusion, either algae species or their blend can be utilized to produce methane gas in a two-phase digestion system.

08/02166 Integrated CHP with autothermal biomass gasification and SOFC–MGT

Fryda, L. *et al. Energy Conversion and Management*, 2008, 49, (2), 281–290.

Autothermal biomass gasification produces a gaseous fuel that, after gas cleaning and conditioning, can be used in solid oxide fuel cells (SOFC). Conceptually, the integrated system can be near atmospheric or at elevated pressures, allowing combination with a micro gas turbine (MGT) expander. This work comparatively investigates three small scale combined heat and power (CHP) configurations that integrate these technologies: (a) gasification at 4 bar and MGT, (b) gasification at 1.4 bar and SOFC and (c) gasification at 4 bar and SOFC–MGT. Aspenplus$^{\mathrm{TM}}$ process simulation software was used for modelling each major and peripheral component of the CHP. Interestingly, the MGT system proved more efficient than the atmospheric SOFC, both of which were surpassed by SOFC–MGT performance that reached an exergetic electrical efficiency of 35.6% using an SOFC of $100\,\mathrm{m^2}$ active surface area and nominal biomass throughput of 200 kg/h. An exergy analysis allowed optimization of the SOFC fuel utilization factor (U_f) and efficiency impact of system capacity and level of product gas moistening prior to the cell.

08/02167 Investigation of bio-ethanol steam reforming over cobalt-based catalysts

Song, H. *et al. Catalysis Today*, 2007, 129, (3–4), 346–354.

The catalytic performance of cobalt catalysts supported on γ-Al_2O_3, TiO_2, ZrO_2 were studied for bio-ethanol steam reforming (BESR) reaction. The supported catalysts (10 wt%Co) were prepared by impregnation and characterized through thermogravimetric analysis (TGA), H_2 chemisorption, laser Raman spectroscopy, diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS), and temperature-programmed reaction (TPRxn). The metallic cobalt sites were found to correlate with the BESR reaction activity. The reaction and H_2 chemisorption showed that ZrO_2 supported catalyst showed the best dispersion and best catalytic activity. Over the 10% Co/ZrO_2 catalyst, using a H_2O:EtOH:inert molar ratio of 10:1:75 and a $\mathrm{GHSV} = 5000\,\mathrm{h^{-1}}$, 100% ethanol conversion and a yield of 5.5 mol H_2/mol EtOH were obtained at 550 °C and atmospheric pressure.

08/02168 Investigation with ^{13}C NMR, EPR and magnetic susceptibility measurements of char residues obtained by pyrolysis of biomass

Bardet, M. *et al. Fuel*, 2007, 86, (12–13), 1966–1976.

Biomass pyrolysis for the production of fuels and chemicals is certainly one of the most promising strategies to replace petro-chemical polymers. Generally the biomass is first pyrolysed using temperature up to 700 °C to obtained vapours that are further cracked using catalysts. The catalyst can be poisoned by tars that are formed during the pyrolysis step and that are entrained with the vapour. In order to understand and model the behaviour of the biomass during such a process, a complete structural study of the chars was performed with high-resolution solid-state ^{13}C, EPR, and susceptibility measurements. The origin of biomass does not affect the nature of the solid residues that are formed during the thermal treatment. They all loose their ligno-cellulosic structure and are transformed to polycyclic material with a preponderance of aromatic structures with proton amounts that decrease drastically as the temperature of treatment increases. The presence of unpaired electrons is undoubtedly indicated with EPR spectroscopy. Most of metallic compounds found in the solid residues are easily removed by a mild acidic treatment. It indicates that they are not intercalated inside the polycyclic plans. The occurrence of ferri/ferromagnetic parts has been clearly shown. Their origin is probably exogenous. The study has revealed some non-classical and unexpected features of the NMR spectra that are presented and discussed in relation to the structural properties of the pyrolysed biomass.

08/02169 Modelling of biofuel droplets dispersion and evaporation

Barata, J. *Renewable Energy*, 2008, 33, (4), 769–779.

Alternative renewable fuels are more and more important due to increasing oil prices, environmental concerns and their potential to preserve the agricultural activity. For the case of biofuels derived from agricultural crops, several possibilities can be considered, such as raw oil, oil-derived methyl esters, bioethanol or mixtures with conventional fuels (diesel fuel or gasoline). The straight use of vegetable oils and their derivates poses some problems on the mixture formation process and droplet evaporation, that are essentially derived from their much higher viscosity (up to five times the viscosity of the diesel fuel) and higher boiling temperature. The present paper presents a numerical study on evaporating biofuel droplets injected through a turbulent cross-stream. This study uses an Eulerian/Lagragian approach to account for turbulent transport, dispersion, evaporation and coupling between both processes in practical spray injection systems, which usually include air flows in the combustion chamber-like swirl, tumble and squish in internal combustion engines or cross-flow in boilers and gas turbines. An array of evaporating biofuel droplets through a cross-flow is studied, and a comparison of the droplet fuel dispersion and evaporation with conventional fuels is performed. The results obtained with DF-2 and RME showed that an homogeneous mixture can only be obtained with very high levels of pre-heating, and the use of ethanol (obtained from sugar or starch crops) may be a better alternative in ignition-assisted combustion systems, while RME can be successfully used as an alternative fuel in applications that utilize diffusion flames.

08/02170 Pentachlorophenol contaminated groundwater bioremediation using immobilized *Sphingomonas* cells inoculation in the bioreactor system

Yang, C.-F. and Lee, C.-M. *Journal of Hazardous Materials*, 2008, 152, (1), 159–164.

Pentachlorophenol (PCP) has been used as a wood preservative for more than 100 years. The extensive use of PCP has widely contaminated soil and groundwater. PCP is toxic to living organisms. The main objective of this research was to inoculate the pure PCP-degrading bacterium strain *Sphingomonas chlorophenolica* PCP-1, isolated from PCP-contaminated soils, into PCP-contaminated groundwater for remediation purposes. The factors that influenced the bioremediation were explored with batch experiments using the inoculated immobilized and suspended cells as inoculation. A biological treatment system inoculated with immobilized cells was set up to estimate the microbial capability to degrade PCP. The results indicated that the suspended and immobilized cells could be inoculated into PCP-contaminated groundwater without adding other supplementary nitrogen and phosphate sources in batch conditions. Moreover, PCP decomposition was accompanied with released Cl^- and decreasing pH value. The optimum HRT in the bioreactor system was 12.6 h. PCP removal in the bioreactor remained stable and PCP removal efficiency was higher than 92% at this phase. Furthermore, PCP concentration in the biotreatment system effluent remained undetectable. It is possible to bioremediate PCP-contaminated groundwater using immobilized *S. chlorophenolica* PCP-1 cells in a bioreactor system. The proposed biological treatment system could be maintained for at least for 2 months.

08/02171 Predicting the viscosity of biodiesel fuels based on the mixture topological index method

Shu, Q. *et al. Fuel*, 2007, 86, (12–13), 1849–1854.

To predict the viscosity of any given biodiesel fuel (FAME mixture), a novel topological index based on the distance matrix and adjacent matrix of the molecular structure is proposed. The new topological index can reflect the information of the molecular structure for fatty acid methyl ester (FAME), such as the size of molecular, unsaturated bond and branch degree. Combined with the modified Grunberg–Nissan or Hind equation, the topological index values of the FAME mixture were calculated. Then, relates the topological index values of the FAME mixtures with the viscosities of them, two linear regression equations were obtained. Using these regression equations, the viscosity of biodiesel fuels were predicted. The results show the modified Grunberg–Nissan equation with a higher precision of prediction than the Hind equation regression equation.

08/02172 Prediction and experimental verification of performance of box type solar cooker. Part II: cooking vessel with depressed lid

Reddy, A. R. and Rao, A. V. N. *Energy Conversion and Management*, 2008, 49, (2), 240–246.

An earlier article (Part I) discussed the theoretical and experimental study of the performance boost obtained by a cooking vessel with central cylindrical cavity on lugs when compared to that of a conventional cylindrical vessel on floor/lugs. This article compares the performance of the cooking vessel with depressed lid on lugs with that of the conventional vessel on lugs. A mathematical model is presented to understand the heat flow process to the cooking vessel and, thereby, to the food material. It is found from the experiments that the cooking vessel with depressed lid results in higher temperature of the thermic fluid loaded in the cooking vessel compared to that of the thermic fluid kept in the conventional vessel when both are placed on lugs. Similar results were obtained by modeling the process mathematically. The average improvement of performance of the vessel with depressed lid is found to be 8.4% better than the conventional cylindrical vessel.

08/02173 Prediction of sorption equilibrium both in air and superheated steam drying of energetic variety of willow *Salix viminalis* in a wide temperature range

Pakowski, Z. *et al. Fuel*, 2007, 86, (12–13), 1749–1757.

Sorption isotherms and isobars of energetic variety of willow *Salix viminalis* in a wide range of temperature and water activity were determined. In order to investigate sorption isobars a specially constructed set-up was built. The sorption isotherms were determined in the water bath and CIsorp water sorption analyser. The experimental data were compared with the literature data. It was found out that water activity of willow as a function of temperature and moisture content can be described by one generalized equation. The equation can be then used for the purpose of prediction of sorption equilibrium during wood drying process in a wide range of temperatures and moisture contents.

08/02174 Production of biodiesel from high free fatty acid Karanja (*Pongamia pinnata*) oil

Naik, M. *et al. Biomass and Bioenergy*, 2008, 32, (4), 354–357.

Non-edible oil contains several unsaponifiable and toxic components, which make them unsuitable for human consumption. Karanja (*Pongamia pinnata*) is an underutilized plant grown in many parts of India. Sometimes the oil is contaminated with high free fatty acids (FFAs) depending upon the moisture content in the seed during collection as well as oil expression. The present study deals with production of biodiesel from high FFA Karanja oil because the conventional alkali-catalysed route is not the feasible route. This paper discusses the mechanism of a dual process adopted for the production of biodiesel from Karanja oil containing FFA up to 20%. The first step is acid-catalysed esterification by using 0.5% H_2SO_4, alcohol 6:1 molar ratio with respect to the high FFA Karanja oil to produce methyl ester by lowering the acid value, and the next step is alkali-catalysed transesterification. The yield of biodiesel from high FFA Karanja oil by dual step process has been observed to be 96.6–97%.

08/02175 Properties of bio-oils produced by biomass fast pyrolysis in a cyclone reactor

Lédé, J. *et al. Fuel*, 2007, 86, (12–13), 1800–1810.

The present paper reports the experimental results of the fast pyrolysis of biomass performed in a cyclone reactor heated at its walls. The conditions of pyroliquefaction are chosen (walls temperature between 900 and 983 K) in order to enhance bio-oils production. Their yields reach 74% while those of char and gases are respectively 10% and 16%. The bio-oils are condensed and trapped at different temperatures. Three main fractions are recovered: heavy oils, light oils and aerosols. Their physicochemical properties (water and particles content, viscosity, density, pH, fraction of pyrolytic lignin and elementary molar composition) as well as stability during storage are measured and compared with literature. The results show very different behaviours according to the types of oils fractions.

08/02176 Refining bioethanol from stalk juice of sweet sorghum by immobilized yeast fermentation

Liu, R. *et al. Renewable Energy*, 2008, 33, (5), 1130–1135.

The relationship between total soluble sugar content and Brix in stalk juice of sweet sorghum was determined through one-dimensional linear regression. Meanwhile, bioethanol fermentation experiments were conducted in shaking flasks and 10 l fluidized bed bioreactor with stalk juice of Yuantian No. 1 sweet sorghum cultivar when immobilized yeast was applied. The experimental results in the shaking flasks showed that the order of influence on improving ethanol yield was $(NH_4)_2SO_4$ > $MgSO_4$ > K_2HPO_4, and the optimum inorganic salts supplement dose was determined as follows: K_2HPO_4 0%, $(NH_4)_2SO_4$ 0.2%, $MgSO_4$ 0.05%. When the optimum inorganic salts supplement dose was used in fermentation in 10 l fluidized bed reactor, the fermentation time and ethanol content were 5 h and 6.2% (v/v), respectively, and ethanol yield was 91.61%, which was increased by 9.73% than blank. In addition, the results showed that the fermentation time was about 6–8 times shorter in fluidized bed bioreactor with immobilized yeast than that of conventional fermentation technology. As a result, it can be concluded that the determined optimum inorganic salts supplement dose could be used as a guide for commercial ethanol production. The fluidized bed bioreactor with immobilized yeast technology has a great potential for ethanol fermentation of stalk juice of sweet sorghum.

08/02177 Slow pyrolysis of pistachio shell

Apaydin-Varol, E. *et al. Fuel*, 2007, 86, (12–13), 1892–1899.

In this study, pistachio shell is taken as the biomass sample to investigate the effects of pyrolysis temperature on the product yields and composition when slow pyrolysis is applied in a fixed-bed reactor at atmospheric pressure to the temperatures of 300, 400, 500, 550, 700 °C. The maximum liquid yield was attained at about 500–550 °C with a yield of 20.5%. The liquid product obtained under this optimum temperature and solid products obtained at all temperatures were characterized. As well as proximate and elemental analysis for the products were the basic steps for characterization, column chromatography, FT-IR, GC/MS and SEM were used for further characterization. The results showed that liquid and solid products from pistachio shells show similarities with high value conventional fuels.

08/02178 Steam pretreatment of dilute H_2SO_4-impregnated wheat straw and SSF with low yeast and enzyme loadings for bioethanol production

Linde, M. *et al. Biomass and Bioenergy*, 2008, 32, (4), 326–332.

Conversion of lignocellulosic material to monomeric sugars and finally ethanol must be performed at low cost, i.e. with limited consumption of chemicals, yeast and enzymes, while still reaching high yields, if it is to compete with other fuel conversion processes. The objective of this study was thus to investigate ethanol production from steam-pretreated wheat straw by simultaneous saccharification and fermentation (SSF). The concentration of sulfuric acid in the impregnation liquid prior to pretreatment was kept low, 0.2%, and SSF was performed at low enzyme loadings, 3–14 FPU g^{-1} water-insoluble solids (WIS), and a low yeast concentration, 2 g L^{-1}. The pretreatment conditions were optimized to give the highest overall glucose and xylose recovery after enzymatic hydrolysis of the residual WIS. The highest recovery of glucose (102%) and xylose (96%) was obtained after pretreatment at 190 °C for 10 min. Achieving high yields of glucose and xylose with the same pretreatment conditions is unusual and makes wheat straw a highly suitable raw material for bioethanol production. SSF was performed on whole slurry from straw pretreated under the optimal conditions. A high overall ethanol yield, 67% of the theoretical based on glucose in the raw material, was obtained.

08/02179 Techno-economic evaluation of bioethanol production from three different lignocellulosic materials

Sassner, P. *et al. Biomass and Bioenergy*, 2008, 32, (5), 422–430.

The lignocellulosic materials spruce (softwood), *Salix* (hardwood) and corn stover (agricultural residue) are all potential feedstock for ethanol production. In this study the utilization of these materials for bioethanol production was compared in terms of production cost and energy demand using a process concept based on SO_2-catalysed steam pretreatment followed by simultaneous saccharification and fermentation (SSF). A model including all major process steps was implemented in the commercial flowsheeting programme Aspen Plus, and the model input was based on data recently obtained on lab-scale or in a process development unit. The main focus of the study was on the pretreatment and the SSF steps. Sensitivity analyses of important process parameters showed their relative effects on the production cost and on the potential for cost reduction for each raw material. The study clearly demonstrates the importance of a high ethanol yield and the necessity of utilizing the pentose fraction for ethanol production to obtain good process economy, especially when using *Salix* or corn stover. Furthermore, a less energy-demanding process, here mainly achieved by increasing the dry matter content in SSF, reduces the capital cost and results in higher co-product credit, and therefore has a significant effect on the overall process economy.

08/02180 Thermogravimetric characterization of corn stover as gasification and pyrolysis feedstock

Kumar, A. *et al. Biomass and Bioenergy*, 2008, 32, (5), 460–467.

Corn stover is an agricultural by-product, which is abundant in quantity. Gasification and pyrolysis are efficient methods of harnessing energy efficiently from corn stover. The performances of mathematical models to predict the product gas quality rely on characterization of feed materials and the reaction kinetics of their thermal degradation. The objective of this research was to determine selected physical and chemical properties of corn stover related to thermochemical conversion. Thermogravimetric analyses were performed at heating rates of 10, 30, and $50\,^{\circ}\mathrm{C\,min^{-1}}$ in nitrogen (inert) and air (oxidizing) atmospheres. The parameters of the reaction kinetics were obtained and compared with other biomass. The weight losses of corn stover in both inert and oxidizing atmospheres were found to occur in three stages.

Geothermal energy

08/02181 An overview of the Awibengkok geothermal system, Indonesia

Stimac, J. *et al. Geothermics*, 2008, 37, (3), 300–331.

The Awibengkok (Salak) geothermal system is a liquid-dominated, fracture-controlled reservoir with benign chemistry and low-to-moderate non-condensable gas content. The geothermal system is hosted mainly by andesitic-to-rhyodacitic rocks, and floored by Miocene marine sedimentary rocks cut by igneous intrusions. The volcanic sequence is capped by an 8400-year-old phreatic explosion breccia, rhyolite fallout tuff (>8400 years and <40,000 years), rhyolite lavas, domes and related tuffs (≥40–120 ka), and dacite-to-rhyodate lavas and domes (185–280 ka) that were erupted across the eastern part of the field from NNE-trending vents controlled by a major fault. More regionally extensive basaltic–andesite to andesite volcanic centres are mostly between 180 and 1610 ka old. Surface and subsurface fault patterns, formation image logs and tracer studies indicate strongly anisotropic permeability aligned with the dominant N to NE fracture trend, dividing the field into a number of subcompartments that are locally connected by fractured aquifers and NW- and E-W-trending fractures. Shallow argillic alteration gives way with increasing depth and temperature to argillic–phyllic and propylitic zones, with the latter accounting for the bulk of the fluid produced from the geothermal system. The commercial Awibengkok reservoir is a moderate-to-high temperature (240–312 °C) geothermal resource with high fracture permeability, moderate porosity (mean = 10.6%) and moderate-to-low matrix permeability (geometric mean = 0.026 md). The principal deep upflow zone, with fluid temperatures in the 275–312 °C range, is located in the western part of the field. The ascending fluids move up along N- or NNE-trending structures that breach low-permeability tuff layers in the central and east-central parts of the field. Fluids in the central part of the reservoir are uniform in composition and temperature, representing the mixing of upflow and convective reflux. Fluids ascend and flow laterally to the shallow top of the reservoir in the eastern area near drilling pads Awi 1 and 13 (fluid production temperatures: 240–270 °C). The eastern reservoir is shallower and has been more affected by volcanic eruptions during the period of hydrothermal activity. This has led to steam loss, condensation, and local ingress of shallow steam-heated water that has resulted in lower temperatures in this area. Delineation of potential fluid production or injection zones adjoining northern and western margins of the proven reservoir has been accomplished by integration of new geophysical, geologic and geochemical studies, followed by drilling. A facies model for small calderas was developed and used during the assessment of the western area.

08/02182 Does more energy consumption bolster economic growth? An application of the nonlinear threshold regression model

Huang, B.-W. *et al. Energy Policy*, 2008, 36, (2), 755–767.

This paper separates data extending from 1971 to 2002 into the energy crisis period (1971–1980) and the post-energy crisis period (1981–2000) for 82 countries. The cross-sectional data (yearly averages) in these two periods are used to investigate the non-linear relationships between energy consumption growth and economic growth when threshold variables are used. If threshold variables are higher than certain optimal threshold levels, there is either no significant relationship or else a significant negative relationship between energy consumption and economic growth. However, when these threshold variables are lower than certain optimal levels, there is a significant positive relationship between the two. In 48 out of the 82 countries studied, none of the four threshold variables is found to be higher than the optimal levels. It is inferred that these 48 countries should adopt a more aggressive energy policy. As for the other 34 countries, at least one threshold variable is higher than the optimal threshold level and thus these countries should adopt energy policies with varying degrees of conservation based on the number of threshold variables that are higher than the optimal threshold levels.

08/02183 History of geothermal exploration in Indonesia from 1970 to 2000

Hochstein, M. P. and Sudarman, S. *Geothermics*, 2008, 37, (3), 220–266.

Reconnaissance surveys undertaken since the 1960s show that more than 200 geothermal prospects with significant active surface manifestations occur throughout Indonesia. Some 70 of these were identified by the mid-1980s as potential high-temperature systems using geochemical criteria of discharged thermal fluids. Between 1970 and 1995, about 40 of these were explored using geological mapping, geochemical and detailed geophysical surveys. Almost half of the surveyed prospects were tested by deep (0.5–3 km) exploratory drilling, which led to the discovery of 15 productive high-temperature reservoirs. Several types of reservoirs were encountered: liquid-dominated, vapour-dominated, and a vapour layer/liquid-saturated substratum type. All three may be modified by upflows (plumes) containing magmatic fluid components (volcanic geothermal systems). Large, concealed outflows are a common feature of liquid-dominated systems in mountainous terrain. All explored prospects are hosted by Quaternary volcanic rocks, associated with arc volcanism, and half occur beneath the slopes of active or dormant stratovolcanoes. By 1995, five fields had been developed by drilling of production wells; three of them supplied steam to plants with a total installed capacity of $305\,\mathrm{MW_e}$. By 2000, with input from foreign investors, the installed capacity had reached 800 MWe in six fields, but geothermal developments had stalled because of the 1997–1998 financial crisis.

08/02184 Modeling of a geothermal standing column well

Abu-Nada, E. *et al. International Journal of Energy Research*, 2008, 32, (4), 306–317.

This paper presents a three-dimensional numerical investigation of a geothermal standing column well (SCW) to carry out heating simulations during January in four selected locations in Jordan. It is shown that the outlet temperature of SCW increases with the depth of the borehole. However, the successful choice of the location is of extreme importance as there is a limit on the outlet temperature that can be achieved at a given location. It is demonstrated that bleeding is generally effective in increasing the outlet temperature. An optimum range of bleed rate exists around 12–13%. Also, bleeding is more effective in achieving higher outlet temperatures when used in locations with higher soil porosity.

08/02185 Modelling and automatic reactive power control of isolated wind-diesel hybrid power systems using ANN

Bansal, R. C. *Energy Conversion and Management*, 2008, 49, (2), 357–364.

This paper presents an artificial neural network (ANN)-based approach to tune the parameters of the static var compensator (SVC) reactive power controller over a wide range of typical load model parameters. The gains of proportional integral based SVC are optimized for typical values of the load voltage characteristics (n_q) by conventional techniques. Using the generated data, the method of multi-layer feed forward ANN with error back propagation training is employed to tune the parameters of the SVC. An ANN tuned SVC controller has been applied to control the reactive power of a variable slip/speed isolated wind-diesel hybrid power system. It is observed that the maximum deviations of all parameters are more for larger values of n_q. It has been shown that initially synchronous generator supplies the reactive power required by the induction generator and/or load, and the latter reactive power is purely supplied by the SVC.

08/02186 Numerical and experimental assessment of thermal performance of vertical energy piles: an application

Gao, J. *et al. Applied Energy*, 2008, 85, (10), 901–910.

A district space heating and cooling system using geothermal energy from bearing piles was designed in Shanghai and will be installed in two years before 2010. This paper describes the pile-foundation heat exchangers applied in an energy pile system for an actual architectural complex in Shanghai, 30% of whose cooling/heating load was designed to be provided by a ground-source heat pump (GSHP) system using the energy piles. In situ performance tests of heat transfer are carried out to figure out the most efficient type of energy pile and to specify the design of energy pile system. Numerical investigation is also performed to confirm the test results and to demonstrate the medium temperature variations along the pipes. The averaged heat resistance and heat injection rate of different types of energy piles are calculated from the test and numerical results. The effect of pile type, medium flow rate and inlet temperature on thermal performance is separately discussed. From the viewpoint of energy efficiency and adjustability, the W-shaped underground heat exchanger with moderate medium flow rate is finally adopted for the energy pile system.

08/02187 Overview of the Wayang Windu geothermal field, West Java, Indonesia

Bogie, I. *et al. Geothermics*, 2008, 37, (3), 347–365.

The Wayang Windu geothermal field, West Java, Indonesia, is interpreted to be transitional between vapour-dominated and liquid-dominated conditions with four coalesced fluid upwelling centres that generally become younger and more liquid-dominated towards the south. Two of these centres are associated with the large Gunung Malabar andesite stratovolcano and the other two with the smaller aligned Gunung Wayang and Gunung Windu andesitic volcanoes to the south. The overall potential resource area is of the order of 40 km^2. Deep wells encounter a deep liquid reservoir whose top, which ranges from 0 to 400 m above sea level (m asl) becomes progressively deeper toward the south. As pressure versus elevation conditions are the same throughout the deep liquid reservoir it is likely to be contiguous. This liquid-dominated reservoir is overlain by three separate vapour-dominated reservoirs. The northernmost is the largest as it is coalesced over two separate fluid upwelling centres. Its low gas content, size, prolonged productivity and isobaric for elevation nature, preclude it from being a parasitic steam zone. Mineralogical relationships demonstrate that this vapour zone was originally liquid-dominated with a deep water level as high as 1700 m asl. Subsequent boil off may reflect low recharge rates due to hydrological isolation at depth. To the south, the vapour-dominated reservoirs decrease in thickness and are characterized by progressively higher pressures, temperatures and gas contents. These changes suggest that the southernmost vapour-dominated zone is the youngest and that these zones become increasing older to the north.

08/02188 Primary energy and comfort performance of ventilation assisted thermo-active building systems in continental climates

Henze, G. P. *et al. Energy and Buildings*, 2008, 40, (2), 99–111.

This article presents a simulation study comparing the primary energy and comfort performance of ventilation assisted thermo-active building systems (TABS) relative to a conventional all-air (VAV) system in a compact office building featuring good thermal envelope performance, heat recovery, and solar gain control for the continental climate of Omaha, Nebraska with pronounced heating and cooling periods. TABS heating is accomplished using a geothermal heat pump and TABS cooling using a geothermal heat exchanger without an additional vapour compression cycle required. It was found that the coordination of the TABS and VAV systems is crucial, i.e. supply air temperature and active layer temperature setpoints and reset schedules greatly affect the performance of the overall system. The small contribution of TABS in the heating case shows the need for the adaptation of the ventilation system configuration to the TABS system. Annual cooling energy demand for the ventilation assisted TABS is higher than for the pure VAV system, which is due to lower occupied period room operative temperatures and thus a higher comfort provided. While a 4% useful energy penalty for the combined TABS/VAV was recorded, the VAV case requires 20% more delivered energy than the TABS case because of the displacement of compressor driven coil loads with low-exergy cooling through the ground heat exchanger in the TABS case. A primary energy intensity of 189 kWh/m^2 a was recorded for the TABS case; in contrast, the conventional all-air equipped building incurs a primary energy intensity of 229 kWh/m^{2}a, which represents a penalty of 20%. Clear advantages of the TABS approach can be observed with respect to thermal comfort: during summer cooling periods, the mean radiant temperature of the TABS case is on average 2 K below that of the VAV case. Moreover, the VAV system is associated with a fairly constant predicted mean vote value of 0.75, which is quite warm, while the TABS equipped system reveals an average of 0.56, which results in only 12% instead of 17% of people dissatisfied. Based on these results, ventilation assisted thermo-active cooling systems appear to be a very promising alternative to conventional all-air systems offering both significant primary energy as well as thermal comfort advantages provided the TABS is mated with low-exergy heating and cooling sources.

08/02189 Spatial data analysis and integration for regional-scale geothermal potential mapping, West Java, Indonesia

Carranza, E. J. M. *et al. Geothermics*, 2008, 37, (3), 267–299.

Conceptual modelling and predictive mapping of potential for geothermal resources at the regional-scale in West Java are supported by analysis of the spatial distribution of geothermal prospects and thermal springs, and their spatial associations with geologic features derived from publicly available regional-scale spatial data sets. Fry analysis shows that geothermal occurrences have regional-scale spatial distributions that are related to Quaternary volcanic centres and shallow earthquake epicentres. Spatial frequency distribution analysis shows that geothermal occurrences have strong positive spatial associations with Quaternary volcanic centres, Quaternary volcanic rocks, quasi-gravity lows, and NE-, NNW-, WNW-trending faults. These geological features, with their strong positive spatial associations with geothermal occurrences, constitute spatial recognition criteria of regional-scale geothermal potential in a study area. Application of data-driven evidential belief functions in GIS-based predictive mapping of regional-scale geothermal potential resulted in delineation of high potential zones occupying 25% of West Java, which is a substantial reduction of the search area for further exploration of geothermal resources. The predicted high potential zones delineate about 53–58% of the training geothermal areas and 94% of the validated geothermal occurrences. The results of this study demonstrate the value of regional-scale geothermal potential mapping in: (a) data-poor situations, such as West Java, and (b) regions with geotectonic environments similar to the study area.

Solar energy

08/02190 A combined active anti-islanding method for photovoltaic systems

Yu, B. *et al. Renewable Energy*, 2008, 33, (5), 979–985.

In a modern power system, photovoltaic as distributed generated source is growing larger and it can cause a variety of problems. The most important problem is that of the islanding phenomenon. In order to prevent islanding phenomenon, three kinds of active islanding detection methods have been studied. These are, respectively, to change magnitude, frequency, and the start phase of inverter output current. Among those, both a frequency variation method and a start-phase variation anti-islanding method make the islanding frequency drift away from the trip window of the frequency relay if islanding occurs. This paper presents a novel combined active anti-islanding method, which consists of a frequency variation method active frequency drift and a start-phase variation method slip-mode frequency shift. Clearly, the proposed anti-islanding method shows the islanding detection ability to IEEE 1547 Standard. To validate the performance of the proposed method, simulations and experiments were performed. Possible islanding conditions are implemented with a unity quality factor by the IEEE Standard 1547. The methodology presented can be extended to the other active anti-islanding methods.

08/02191 Artificial neural network estimation of global solar radiation using air temperature and relative humidity

Rehman, S. and Mohandes, M. *Energy Policy*, 2008, 36, (2), 571–576.

Measured air temperature and relative humidity values between 1998 and 2002 for Abha city in Saudi Arabia were used for the estimation of global solar radiation (GSR) in future time domain using artificial neural network method. The estimations of GSR were made using three combinations of data sets namely: (i) day of the year and daily maximum air temperature as inputs and GSR as output, (ii) day of the year and daily mean air temperature as inputs and GSR as output and (iii) time day of the year, daily mean air temperature and relative humidity as inputs and GSR as output. The measured data between 1998 and 2001 were used for training the neural networks while the remaining 240 days' data from 2002 as testing data. The testing data were not used in training the neural networks. Obtained results show that neural networks are well capable of estimating GSR from temperature and relative humidity. This can be used for estimating GSR for locations where only temperature and humidity data are available.

08/02192 Characterisation and design methods of solar cookers

Schwarzer, K. and da Silva, M. E. V. *Solar Energy*, 2008, 82, (2), 157–163.

The use of solar cookers is much needed in many regions with good solar radiation intensity throughout the world. The reasons are economical, as the price of fuel for cooking is no longer affordable by many families; ecological, as in many regions deforestation is also associated with the use of wood as an energy source; and social, as the money used to buy fuel could be used to buy food, medications and other needs to improve the quality of life. Because of the variety of solar cookers that has been presented in the literature, a general procedure to compare these cookers with one another is very complex. This article presents the general types of solar cookers, their basic characteristics, and experimental procedures to test the different types of solar cookers. The variables measured in these procedures are necessary to calculate parameters, which are used to compare the thermal performance of the solar cookers. In addition to these experimental procedures, a simplified analytical model is presented to design simple cooking systems. For more complex systems, results are shown and references are indicated in the text.

08/02193 Collector efficiency improvement of recyclic double-pass sheet-and-tube solar water heaters with internal fins attached

Ho, C. D. and Chen, T. C. *Renewable Energy*, 2008, 33, (4), 655–664.

The sheet-and-tube solar water heater is a convenient and common heater to be used as domestic hot water heating. This paper investigates the effects on collector efficiency of a double-pass sheet-and-tube solar water heater with fins attached under various arrayed density. In addition, the number of pair ducts and total mass flow rate are taken into account during the calculation procedure. The theoretical prediction shows that the higher collector efficiency is obtained under the suitable designing and operating parameters. Considerable improvement in collector performance is obtained by employing a recyclic operation with fins attached and under various arrayed density, instead of employing a single-pass flat-plate device. The effect of the recycle ratio, arrayed density and number of fins attached on the collector efficiency enhancement as well as the power consumption increment has also delineated.

08/02194 Determination of atmospheric parameters to estimate global radiation in areas of complex topography: generation of global irradiation map

Batlles, F. J. *et al. Energy Conversion and Management*, 2008, 49, (2), 336–334.

Incoming shortwave solar radiation is an important parameter in environmental applications. A detailed spatial and temporal analysis of global solar radiation on the earth surface is needed in many applications, ranging from solar energy uses to the study of agricultural, forest and biological processes. At local scales, the topography is the most important factor in the distribution of solar radiation on the surface. The variability of the elevation, the surface orientation and the obstructions due to elevations are a source of great local differences in insolation and, consequently, in other variables as ground temperature. For this reason, several models based on GIS techniques have been recently developed, integrating topography to obtain the solar radiation on the surface. In this work, global radiation is analysed with the Solar Analyst, a model implemented on ArcView, that computes the topographic parameters: altitude, latitude, slope and orientation (azimuth) and shadow effects. Solar Analyst uses as input parameters the diffuse fraction and the transmittance. These parameters are not usually available in radiometric networks in mountainous areas. In this work, a method to obtain both parameters from global radiation is proposed. Global radiation data obtained in two networks of radiometric stations is used: one located in Sierra Mágina Natural Park (Spain) with 11 stations and another one located on the surroundings of Sierra Nevada Natural Park (Spain) with 14 stations. Daily solar irradiation is calculated from a digital terrain model (DTM), the daily diffuse fraction, *K*, and daily atmospheric transmittivity, τ. Results provided by the model have been compared with measured values. An overestimation for high elevations is observed, whereas low altitudes present underestimation. The best performance was also reported during summer months, and the worst results were obtained during winter. Finally, a yearly global solar irradiation map has been produced for the studied zone.

08/02195 Development of a neural network-based fault diagnostic system for solar thermal applications

Kalogirou, S. *et al. Solar Energy*, 2008, 82, (2), 164–172.

The objective of this work was to present the development of an automatic solar water heater (SWH) fault diagnosis system (FDS). The FDS system consisted of a prediction module, a residual calculator and the diagnosis module. A data acquisition system measured the temperatures at four locations of the SWH system and the mean storage tank temperature. In the prediction module a number of artificial neural networks (ANN) were used, trained with values obtained from a TRNSYS model of a fault-free system operated with the typical meteorological year (TMY) for Nicosia, Cyprus and Paris, France. Thus, the neural networks were able to predict the fault-free temperatures under different environmental conditions. The input data to the ANNs were various weather parameters, the incidence angle, flow condition and one input temperature. The residual calculator received both the current measurement data from the data acquisition system and the fault-free predictions from the prediction module. The system could predict three types of faults; collector faults and faults in insulation of the pipes connecting the collector with the storage tank and these were indicated with suitable labels. The system was validated by using input values representing various faults of the system.

08/02196 Dynamical converters with power-producing relaxation of solar radiation

Sieniutycz, S. *International Journal of Thermal Sciences*, 2008, 47, (4), 495–505.

Thermodynamics is applied in mathematical simulation and optimization of non-linear energy converters, in particular radiation engines, in steady and dynamical situations. Power is a cumulative effect maximized in a system with a non-linear fluid, an engine or a sequence of engines, and an infinite bath. Dynamical state equations are applied to describe the resource temperature and work output in terms of a process control. Recent expressions for efficiency of imperfect converters are used to derive and solve Hamilton–Jacobi equations describing resource upgrading and downgrading. Various mathematical tools are applied in trajectory optimization with special attention given to the relaxing radiation. The radiation relaxation curve is non-exponential, characteristic of a non-linear system. Power optimization algorithms in the form of Hamilton–Jacobi–Bellman equations lead to work limits and generalized availabilities. Converter's performance functions depend on end thermodynamic coordinates and a process intensity index, *h*, in fact, the Hamiltonian of power optimization problem. As an example of limiting work from radiation, a finite rate exergy of radiation fluid is estimated in terms of finite rates quantified by Hamiltonian *h*.

08/02197 Energetic and exergetic analysis of a domestic water tank with phase change material

Solé, C. *et al. International Journal of Energy Research*, 2008, 32, (3), 204–214.

Although water is a cheap and effective medium for thermal energy storage, other options are currently being studied to increase the storage density or to reduce the cost of the storage. The authors have been developing a system that combines the advantages of stratified sensible heat storage and latent, phase change heat storage; i.e. a hot water storage tank with stratification where a phase change material (PCM) is included into a spiral tube installed in the top of the tank. The PCM used was a granular PCM-graphite compound of about 90 vol.% of sodium acetate trihydrate and 10 vol.% graphite. This paper presents the results of an experimental investigation of the performance of the new storage concept, and of a conventional hot water storage tank for comparison. The data are further analysed with respect to the energetic and exergetic performance of the two systems.

08/02198 Equations for estimating global solar radiation in data sparse regions

Chineke, T. C. *Renewable Energy*, 2008, 33, (4), 827–831.

The knowledge of the amount of solar radiation in an area/region is very essential in the field of solar energy physics. In this work two equations are put forward for estimating global solar radiation from common climate variables in data sparse regions. The first is the Hargreaves equation, $R_s = 0.16 R_a {T_d}^{0.5}$ where R_a is the extraterrestrial solar radiation and T_d is the temperature difference (maximum minus minimum), while the second is the Ångstrom equation, $R_s = R_a (0.28 + 0.39 n/N)$ where *n* and *N* are the measured sunshine hours and the maximum daylight duration respectively. The global solar radiation estimated by the two equations for three sites, Owerri (5°28′N, 7°2′E), Umudike (5°29′N, 7°33′E) and Ilorin (8°32′N, 4°46′E), located in different climate zones of in Nigeria, West Africa, are in agreement with those of earlier workers and that from photovoltaic geographic information system project. The implication of this in solar photovoltaic applications has been stressed.

08/02199 Evaluation of sunshine duration from cloud data in Egypt

Robaa, S. M. *Energy*, 2008, 33, (5), 785–795.

In this study, three empirical formulae have been deduced to estimate relative sunshine duration, n/N, using readily available observed data of cloud amount, *C*, in Egypt. The monthly mean values of n/N and *C* recorded at 34 stations during the period (1990–2005) have been used in the present study. The three deduced formulae have been verified for any locality in Egypt which lies above (zone 1) and below latitude 30°

(zone 2) and for the whole country of Egypt. The agreement between measured and estimated values of the three deduced formulae were remarkable. It was found that the maximum possible error of estimated values, e (%), of the three deduced empirical formulae have not exceeded ±7.27% with mean percentage error (MPE) values range from -0.62% to $+0.81\%$; meanwhile the values of statistical tests of main bias error (MBE) and root mean square error (RMSE) are very close to zero. It has been concluded that Egypt's deduced formula gives precise estimations for n/N and was recommended for use at any location in Egypt. The sunshine distribution and its percentage frequency over Egypt were also studied. The results revealed that latitudinal dependent of n/N. Egypt has minimum value of n/N (0.48) during January at the northern part of the country and maximum value (0.92) during June at the southern part.

08/02200 Exergoeconomic analysis of glycol cold thermal energy storage systems

Bakan, K. *et al. International Journal of Energy Research*, 2008, 32, (3), 215–225.

An exergoeconomic analysis of glycol cold thermal energy storage (CTES) is reported. Glycol CTES is an application of sensible heat storage where the temperature of a storage material changes in order to store cold energy, usually generated from electricity when its cost is low. Exergoeconomic analysis combines thermodynamic analysis based on the first and second laws with principles of economics, mostly cost accounting. Exergy analysis accounts for energy quality and irreversibilities, and provides more meaningful and useful information than energy analysis about efficiency and losses. A storage tank with a capacity of 350,000 kg is considered for this investigation and a water solution based on ethylene glycol is used as the storage medium. Several thermodynamic system factors are analysed, such as change in storage temperature, coefficient of performance (COP) of the chiller, heat losses from the storage tank, and the mass flow rates. Simulation results indicate that the system exergy efficiency is much less ($\sim$45%) than the energy efficiency. The average exergy efficiency of the storage tank is determined to be 35% and the average energy efficiency 80%. The system exergy efficiency is determined to be 30% and 40% at 45 and 25°C ambient temperatures, respectively. The chiller COP is observed to be strongly related to storage temperature, and to vary approximately between 2.4 and 5.8 at a 35°C ambient temperature. As ambient temperature decreases, COP increases. The exergoeconomic analysis indicates that the ratio of exergy-based thermodynamic loss to capital cost of the glycol CTES ranges from 0.00233 to $0.00225\,\text{kW}\,\$^{-1}$ at a 35°C reference environment temperature, and from 0.00235 to $0.00227\,\text{kW}\,\$^{-1}$ at a 25°C reference environment temperature. The reference environment temperature affects significantly exergy destruction and efficiency, e.g. a 10°C change in ambient temperatures. Heat loss from the storage tank exhibits a mild dependence on ambient temperature, e.g. a 10°C increase in ambient temperature causes a heat loss increase of 7.1%.

08/02201 Exergy analysis of a passive solar still

Torchia-Núñez, J. C. *et al. Renewable Energy*, 2008, 33, (4), 608–616.

This paper presents a steady-state and transient theoretical exergy analysis of a solar still, focused on the exergy destruction in the components of the still: collector plate, brine and glass cover. The analytical approach states an energy balance for each component resulting in three coupled equations where three parameters – solar irradiance, ambient temperature and insulation thickness – are studied. The energy balances are solved to find temperatures of each component; these temperatures are used to compute energy and exergy flows. Results in the steady-state regime show that the irreversibilities produced in the collector account for the largest exergy destruction, up to 615 W/m^2 for a 935 W/m^2 solar exergy input, whereas irreversibility rates in the brine and in the glass cover can be neglected. For the same exergy input a collector, brine and solar still exergy efficiency of 12.9%, 6% and 5% are obtained, respectively. The most influential parameter is solar irradiance. During the transient regime, irreversibility rates and still temperatures find a maximum 6 h after dawn when solar irradiance has a maximum value. However, maximum exergy brine efficiency, close to 93%, is found once $T_{\text{col}} < T_{\text{w}}$ (dusk) and the heat capacity of the brine plays an important role in the modelling of collector–brine interaction. Nocturnal distillation is characterized by very low irreversibility rates due to reduced temperature difference between collector and an increase in exergy efficiency towards dawn due to ambient temperature decrease.

08/02202 Experience with fully operational solar-driven 10-ton $LiBr/H_2O$ single-effect absorption cooling system in Thailand

Pongtornkulpanich, A. *et al. Renewable Energy*, 2008, 33, (5), 943–949.

A solar-driven 10-ton $LiBr/H_2O$ single-effect absorption cooling system has been designed and installed at the School of Renewable Energy Technology (SERT), Phitsanulok, Thailand. Construction took place in 2005, after which this system became fully operational and has been supplying cooling for the main testing building's air-conditioning. Data on the system's operation were collected during 2006 and analysed to find the extent to which solar energy replaced conventional energy sources. Here, this data is presented and shows that the 72 m^2 evacuated tube solar collector delivered a yearly average solar fraction of 81%, while the remaining 19% of thermal energy required by the chiller was supplied by a LPG-fired backup heating unit. It is also shown that the economics of this cooling system are dominated by the initial cost of the solar collector array and the absorption chiller, which are significantly higher than that of a similar-size conventional VCC system.

08/02203 Experimental investigation on heat-transfer enhancement due to a gap in an inclined continuous rib arrangement in a rectangular duct of solar air heater

Aharwal, K. R. *et al. Renewable Energy*, 2008, 33, (4), 585–596.

Artificial roughness in the form of repeated ribs has been proposed as a convenient method for enhancement of thermal performance of solar air heaters. This paper presents the experimental investigation of heat transfer and friction factor characteristics of a rectangular duct roughened with repeated square cross-section split-rib with a gap, on one broad wall arranged at an inclination with respect to the flow direction. The duct has a width to height ratio (W/H) of 5.84, relative roughness pitch (P/e) of 10, relative roughness height (e/D_{h}) of 0.0377, and angle of attack (*) of 60°. The gap width (g/e) and gap position (d/W) were varied in the range of 0.5–2 and 0.1667–0.667, respectively. The heat transfer and friction characteristics of this roughened duct have been compared with those of the smooth duct under similar flow condition. The effect of gap position and gap width has been investigated for the range of flow Reynolds numbers from 3000 to 18,000. The maximum enhancement in Nusselt number and friction factor is observed to be 2.59 and 2.87 times of that of the smooth duct, respectively. The thermo-hydraulic performance parameter is found to be the maximum for the relative gap width of 1.0 and the relative gap position of 0.25.

08/02204 Experimental research on a new solar pump-free lithium bromide absorption refrigeration system with a second generator

Gu, Y. *et al. Solar Energy*, 2008, 82, (1), 33–42.

This paper is concerned with experimental research on a new solar pump-free lithium bromide absorption refrigeration system with a second generator. By using the second generator together with a lunate thermosiphon elevation tube, the required minimum driving temperature of the heat source is only 68 °C compared to above 100 °C in traditional absorption refrigeration systems. Based on the horizontal-tube falling-film method, the performance of the absorber can be enhanced by the second generator due to an increase in the differential concentration of the solution between the inlet and the outlet of the absorber and an increase in the temperature difference between the inlet and the outlet of the cooling water in the absorber. The yield of condensate with the second generator open is increased by 68% compared to that with the second generator closed. The performance of the evaporator is significantly improved due to the increase in temperature drop of the chilled water and the decrease in the outlet temperature of the chilled water. This leads to an improvement of the performance of the overall refrigeration system. The maximum coefficient of performance approaches 0.787.

08/02205 Integration of thermoelectrics and photovoltaics as auxiliary power sources in mobile computing applications

Muhtaroglu, A. *et al. Journal of Power Sources*, 2008, 177, (1), 239–246.

The inclusion of renewable technologies as auxiliary power sources in mobile computing platforms can lead to improved performance such as the extension of battery life. This paper presents sustainable power management characteristics and performance enhancement opportunities in mobile computing systems resulting from the integration of thermoelectric generators and photovoltaic units. Thermoelectric generators are employed for scavenging waste heat from processors or other significant components in the computer's chipset while the integration of photovoltaic units is demonstrated for generating power from environmental illumination. A scalable and flexible power architecture is also verified to effectively integrate these renewable energy sources. This paper confirms that battery life extension can be achieved through the appropriate integration of renewable sources such as thermoelectric and photovoltaic devices.

08/02206 Investigations on stratification devices for hot water heat stores

Andersen, E. *et al. International Journal of Energy Research*, 2008, 32, (3), 255–263.

The significance of the thermal stratification for the energy efficiency of small solar thermal hot water heat stores is pointed out. Exemplary the thermal stratification build-up with devices already marketed as well as with devices still in development has been investigated experimentally and theoretically, taking into account different realistic operation conditions. The methods [selective temperature measurement, non-invasive field measuring methods PIC and LIF, computational fluid dynamics (CFD)] suitable for the experimental and theoretical analysis of thermal stratification devices are introduced.

08/02207 Model development and validation of a solar cooling plant

Zambrano, D. *et al. International Journal of Refrigeration*, 2008, 31, (2), 315–327.

This paper describes the dynamic model of a solar cooling plant that has been built for demonstration purposes using market-available technology and has been successfully operational since 2001. The plant uses hot water coming from a field of solar flat collectors which feed a single-effect absorption chiller of 35 kW nominal cooling capacity. The work includes model development based on first principles and model validation with a set of experiments carried out on the real plant. The simulation model has been done in a modular way, and can be adapted to other solar cooling-plants since the main modules (solar field, absorption machine, accumulators and auxiliary heater) can be easily replaced. This simulator is a powerful tool for solar cooling systems both during the design phase, when it can be used for component selection, and also for the development and testing of control strategies.

08/02208 Models of diffuse solar radiation

Boland, J. *et al. Renewable Energy*, 2008, 33, (4), 575–584.

For some locations both global and diffuse solar radiation are measured. However, for many locations, only global is measured, or inferred from satellite data. For modelling solar energy applications, the amount of radiation on a tilted surface is needed. Since only the direct component on a tilted surface can be calculated from trigonometry, the authors need to have diffuse on the horizontal available. There are regression relationships for estimating the diffuse on a tilted surface from diffuse on the horizontal. Models for estimating the diffuse radiation on the horizontal from horizontal global that have been developed in Europe or North America have proved to be inadequate for Australia. The recent advances are detailed in developing the theoretical framework for the approach reported therein, particularly the use of the logistic function instead of piecewise linear or simple non-linear functions. Additionally, the authors have also constructed a method, using quadratic programming, for identifying values that are likely to be erroneous. This allows us to eliminate outliers in diffuse radiation values, the data most prone to errors in measurement.

08/02209 Optimal control of flow in solar collector systems with fully mixed water storage tanks

Badescu, V. *Energy Conversion and Management*, 2008, 49, (2), 169–184.

The paper deals with optimal flow control in closed loop flat plate solar collector systems. The water storage tank operates in the fully mixed regime. Two design configurations were considered: (A) one serpentine in the tank (for the secondary circuit) and (B) two serpentines in the tank (for both primary and secondary circuits). An indirect optimal control technique based on Pontryagin's maximum principle was implemented. A detailed collector model and realistic meteorological data from both cold and warm seasons were used in applications. Configuration (A) gives better performance than configuration (B) but cannot be used during the cold season at higher geographical latitudes. The optimal operation strategy involves two step up and down jumps between zero and a maximum allowable fluid flow rate in the primary circuit. During days with overcast sky, the pump in the primary circuit operates almost continuously. During days with cloudy or clear sky, the pump often stops. Heat provided to the user increases when the maximum fluid flow rate increases. This applies to both configurations (A) and (B). In the case of configuration (B), the heat provided to the user becomes rather constant at higher flow rates. When a constant flow rate strategy is adopted, there is an optimum ratio between the volume of the storage tank and the area of the solar energy collection surface: $V_s/A \approx 33.3\,\mathrm{L/m^2}$. The optimal control strategy does not exhibit such an optimum: the thermal energy supply to the user (slightly) decreases by increasing the ratio V_s/A.

08/02210 Performance and optimum design analysis of an absorber plate fin using recto-trapezoidal profile

Kundu, B. *Solar Energy*, 2008, 82, (1), 22–32.

This paper establishes a new profile, namely recto-trapezoidal (RT) of an absorber plate fin on the basis of ease of fabrication as well as augmentation of heat transfer rate per unit fin volume. An analytical model has been developed for evaluating the thermal performance and optimum dimensions of an absorber plate fin using this typical profile. The present study is equally suitable for an absorber plate fin having a rectangular, trapezoidal or triangular profile also with consideration of their respective geometrical parameters. The optimization of the RT profile has been cast in a generalized form either by maximizing heat transfer rate for a given fin volume or by minimizing fin volume for a given heat transfer duty. From the optimum design analysis, significant results have been noticed when an additional constraint is imposed with the fin volume. Under this design condition, it may also be highlighted that for an optimal circumstance, the heat transfer rate through a RT profile absorber plate fin is greater than a trapezoidal or triangular profile for the same fin volume. However, this observation may be restricted to the limited values of fin volume only. The optimum design analysis for the RT profiled absorber plate fin has also been studied under the different design constants. Finally, for the variation of all the design variables, optimum design curves have been generated for a wide range of thermo-geometric parameters.

08/02211 Performance improvement of PV/T solar collectors with natural air flow operation

Tonui, J. K. and Tripanagnostopoulos, Y. *Solar Energy*, 2008, 82, (1), 1–12.

The electrical efficiency of a photovoltaic system drops as its operating temperature rises and PV cooling is necessary. The photovoltaic/thermal (PV/T) system is a relatively recent type of solar collector where a circulating fluid of lower temperature than PV module extracts heat from it, cooling the module to improve its output power while the solar pre-heated fluid provides sensible heat. In the present work, air cooling of a commercial PV module configured as PV/T air solar collector by natural flow is presented, where two low cost modification techniques to enhance heat transfer to air stream in the air channel are studied. The considered methods consist of thin metal sheet suspended at the middle or fins attached to the back wall of the air-channel to improve heat extraction from the module. A numerical model was developed and validated against the experimental data obtained from outdoor test campaigns for both glazed and unglazed PV/T prototype models studied. The validation results show good agreement between predicted values and measured data and thus could be used to study analytically the performance of these PV/T air collectors with respect to several design and operating parameters. The modified systems present better performance than the usual type and will contribute to better performance of integrated PV systems for natural ventilation applications in buildings, both space cooling and heating.

08/02212 Properties of chemical vapour deposited nanocrystalline TiO_2 thin films and their use in dye-sensitized solar cells

Shinde, P. S. and Bhosale, C. H. *Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 83–88.

Nanocrystalline titanium dioxide (TiO_2) thin films have been prepared using titanium(IV) isopropoxide as a precursor onto the glass and fluorine doped tin oxide coated glass substrates by chemical vapour deposition technique at 400 °C substrate temperature. X-ray diffraction study confirms the polycrystalline nature of TiO_2 with anatase phase having tetragonal crystal structure. The films are 975 nm thick and transparent having transmittance grater than 80%. Atomic force microscopy (AFM) images reveal the nanocrystalline morphology with grain size of ~200 nm. The film shows a sharp absorption edge near 350 nm. Photoelectrochemical study shows that TiO_2 thin film sensitized with Brown Orange dye is found to exhibit relatively maximum I_{sc} and V_{oc} among the studied dyes. The values of fill factor (FF) and efficiency (η) for the dye-sensitized solar cell (Brown Orange dye-sensitized TiO_2) are 0.54 and 0.17%, respectively. Such films would serve as better prospects for dye-sensitized solar cells.

08/02213 Sensitivity of long-term performance simulations of solar energy systems to the degree of stratification in the thermal storage unit

Arias, D. A. *et al. International Journal of Energy Research*, 2008, 32, (3), 242–254.

This paper investigates the sensitivity of the long-term performance simulations of solar energy systems to the degree of stratification in both liquid and packed-bed storage units. The degree of stratification is controlled by the number of nodes used in finite-difference approximation of the storage system temperature distribution. Short- and long-term simulations of typical water heating and solar thermal power plant systems are conducted. The results indicate that the long-term performance of these systems is far less sensitive to the number of nodes used to represent the degree of stratification than expected based on short-term simulations or experimental data. An explanation is offered for this non-intuitive result.

08/02214 Solar radiation modelling for the simulation of photovoltaic systems

Deb Mondol, J. *et al. Renewable Energy*, 2008, 33, (5), 1109–1120.

The effect of 12 different combinations of diffuse–global correlations and tilted surface radiation models on the accuracy of photovoltaic (PV) output simulation of a grid-connected PV system was studied using statistical methods. A site specific diffuse–global correlation was developed using local insolation data and the performance of this model was compared with those of two other diffuse–global correlations. The impact of diffuse–global correlations on the calculated inclined insolation for four different tilted surface radiation models was investigated on annual, seasonal and monthly basis. The accuracies of predicted 45° inclined plane insolation and PV output were improved when the site specific diffuse–global correlation was used in the main simulation model. The error between measured and predicted inclined insolation was higher in winter than summer. The prediction of PV output was improved by using an isotropic sky tilted surface radiation model instead of the anisotropic models. The accuracy of PV output was also improved when the proposed diffuse–global correlation was used.

08/02215 Studies of the pulse charge of lead-acid batteries for PV applications Part I. Factors influencing the mechanism of the pulse charge of the positive plate

Kirchev, A. *et al. Journal of Power Sources*, 2008, 177, (1), 217–225.
The mechanism of the positive plate charge in pulse regime was studied in model lead-acid cells with one positive and two negative plates (8 Ah each) and Ag/Ag_2SO_4 reference electrodes. The results showed that the evolution of the electrode potential is much slower on the positive plate than on the negative plate. Regardless of this fact, the calculated capacitive current of charge and self-discharge of the electrochemical double layer (EDL) during the 'on' and 'off' half-periods of the pulse current square waves is comparable with the charge current amplitude. The result is due to the high values of the EDL on the surface of the lead dioxide active material. The influence of different factors like state of charge, state of health, pulse frequency, current amplitude and open circuit stay before the polarization was discussed. The previously determined optimal frequency of 1 Hz was associated with a maximum in the average double layer current on frequency dependence. The average double layer current is also maximal at SOC between 75 and 100%. The exchange of the constant current polarization with pulse polarization does not change substantially the mechanism and the overvoltage of the oxygen evolution reaction on the positive plate. The mechanism of the self-discharge of the EDL was also estimated analysing long-time PPP transients (up to 2 h). It was found that when the PPP is lower than 1.2 V the preferred mechanism of EDL self-discharge is by coupling with the lead sulfate oxidation reaction. At higher values of PPP the EDL self-discharge happens via oxygen evolution. The high faradic efficiency of the pulse charge is due to the chemical oxidation of the Pb(II) ions by the O atoms and OH radicals formed at the oxygen evolution both during the 'on' and 'off' periods.

08/02216 Study of the distribution of the absorbed solar radiation on the performance of a CPC-type ICS water heater

Souliotis, M. and Tripanagnostopoulos, Y. *Renewable Energy*, 2008, 33, (5), 846–858.
An integrated collector storage (ICS) solar water heater was designed, constructed and studied with an emphasis on its optical and thermal performance. The ICS system consists of one cylindrical horizontal tank properly mounted in a stationary symmetrical compound parabolic concentrating (CPC) reflector trough. The main objective was the design and the construction of a low cost solar system with improved thermal performance based on the exploitation of the non-uniform distribution of the absorbed solar radiation on the cylindrical storage tank surface. A ray-tracing model was developed to gauge the distribution of the incoming solar radiation on the absorber surface and the results were compared with those from a theoretical optical model based on the average number of reflections. The variation of the optical efficiency as function of the incident angle of the incoming solar radiation along with its dependence on the month during annual operation of ICS system is presented. The ICS device was experimentally tested outdoors during a whole year in order to correlate the observed temperature rise and stratification of the stored water with the non-uniform distribution of the absorbed solar radiation. The results show that the upper part of the tank surface collects the larger fraction of the total absorbed solar radiation for all incident angles throughout the year. This is found to have a significant effect on the overall thermal performance of the ICS unit. In addition, the presented results can be considered important for the design and the operation of ICS systems consisting of cylindrical tank and CPC reflectors.

08/02217 Technical and economic evaluation of the utilization of solar energy at South Africa's SANAE IV base in Antarctica

Olivier, J. R. *et al. Renewable Energy*, 2008, 33, (5), 1073–1084.
The technical and economic feasibility of utilizing solar energy at South Africa's SANAE IV station in Antarctica was evaluated in order to estimate potential financial and external savings, and to alleviate the programme's dependence on the special blend of diesel shipped annually from Cape Town. The average global horizontal and tilted insolation rates at the base were studied, energy consumption data of the station was investigated, technical performance characteristics of devices for harnessing solar energy were assessed and an economic analysis was completed. It was shown that at SANAE IV flat-plate solar thermal collectors could potentially be used in conjunction with the snow smelter (a device that meets the station's fresh water demand) and that photovoltaic modules could feasibly be used to reduce the station's electrical demand. Flat-plate solar thermal collectors could collect solar energy at an average of 3.13 R/kWh (viz. 0.49 US$/kWh) from a suggested 143 m^2 array, while comparatively a 40 kWp photovoltaic system would be less economically sound and only able to pay back costs at the end of the system's expected 25-year lifetime, generating electricity at an estimated 3.20 R/kWh (annual electrical consumption at SANAE IV amounts to more than 1062 MWh). The total diesel savings of the solar thermal and photovoltaic systems were estimated at approximately 12,245 and 9958 l, respectively, which represent savings in externalities of R67,338 and R55,879 each.

08/02218 Theory and experiment of a two-dimensional cone concentrator for sunlight

Kiatgamolchai, S. and Chamni, E. *Solar Energy*, 2008, 82, (2), 111–117.
A two-dimensional cone concentrator for sunlight was theoretically and experimentally studied. The calculation revealed the maximum number of reflections that sunlight could make before exiting the cone. A higher number of reflections caused the sunlight to bounce backward to the entrance of the cone. The characteristics and geometric parameters of the cone were assessed. As the cone angle increased from 45° to 90°, the calculated concentration ratio, taking the reflection coefficient into account, increased non-linearly from one to infinity, while the height of the cone also increased from zero to infinity. The experimental concentration ratio was found to be less than the theoretical one in all cases.

08/02219 Thermal behavior of curved roof buildings exposed to solar radiation and wind flow for various orientations

Hadavand, M. and Yaghoubi, M. *Applied Energy*, 2008, 85, (8), 663–679.
In this study air flow, solar radiation and heat transfer from a two dimensional curved roof with north-south and east-west faced are determined and results are compared with flat roof for the same size and orientation. Comparison are performed for their corresponding roof surface temperature, and heat flow for several roof rim angles and also for various wind flow velocities, as well as for different wind directions. Turbulence is modelled by RNG k–ε method and solar radiation distribution over the roof is determined based on an appropriate model applicable to hot arid regions of Iran. Solar radiation is calculated based on the summation of beam and diffuse radiation and ground reflected radiation. For certain inside roof temperature, over all heat transfer to the building is determined with day time for various wind flows and arc shapes and results are compared with flat roof. It was found that various wind flow condition over the vaulted roof makes substantial difference on the convection heat transfer coefficient and finally on the rate of heat transfer to the building with respect to flat roof. Based on heat transfer simulation, roof temperature, heat transfer convection coefficient and heat flow though the vault for different roof arrangement and flat roofs have been determined and advantages of specific vault orientation and wind direction are specified.

08/02220 Thermally and light-activated current in ZnO/CdS/$CuGaSe_2$ single crystal solar cells

Saad, M. and Kassis, A. *Renewable Energy*, 2008, 33, (5), 974–978.
Current–voltage characteristics of ZnO/CdS/$CuGaSe_2$ single crystal solar cells which have gone through repetitive annealing treatment were analysed using the two-diode equation. The fitting analysis revealed that current transport in these cells is governed by two competing transport mechanisms relating strongly to interface states and that both mechanisms are thermally and light-activated. The activation energy values for both mechanisms were calculated from the temperature dependence of the parameters describing each of them. Furthermore, it was found that the calculated activation energy values depend on temperature and illumination intensity. A qualitative explanation for this dependence is given.

08/02221 Towards a local learning (innovation) model of solar photovoltaic deployment

Shum, K. L. and Watanabe, C. *Energy Policy*, 2008, 36, (2), 508–521.
It is by now familiar that in the deployment of solar photovoltaic (PV) systems, the cost dynamics of major system component like solar cell/module is subjected to experience curve effects driven by production learning and research and development at the supplier side. What is less clear, however, is the economics of system integration or system deployment that takes place locally close to the user, involving other market players, in the downstream solar PV value chain. Experts have agreed that suppliers of solar PV system must customize their flexible

characteristics to address local unique users' and applications requirements and compete on price/performance basis. A lack of understanding of the drivers of the economics of system customization therefore is a deficiency in the understanding of the overall economics of this renewable energy technology option. The authors studied the non-module BOS cost for grid-connected small PV system using the experience curve framework. Preliminary analysis of PV statistics of the USA from IEA seems to suggest that learning in one application type is taking place with respect to the cumulative installation among all types of grid-connected small PV projects. The effectiveness of this learning is also improving over time. A novel aspect is the interpretation of such experience curve effect or learning pattern. The authors draw upon the notion of product platform in the industrial management literature and consider different types of local small-scale grid-tied PV customization projects as adapting a standard platform to different idiosyncratic and local application requirements. Economics of system customization, which is user-oriented, involves then a refined notion of inter-projects learning, rather than volume-driven learning by doing. The authors formalized such inter-projects learning as a dynamic economy of scope, which can potentially be leveraged to manage the local and downstream aspect of PV deployment. This dynamic economy may serve as a focus of energy policy having implications on standardization of design and training for installation, facilitating knowledge reuse among different integration projects and enabling inter-projects learning.

08/02222 Use of neural networks for the creation of hourly global and diffuse solar irradiance data at representative locations in Greece

Moustris, K. *et al. Renewable Energy*, 2008, 33, (5), 928–932.

In this work, a new approach is tested by applying neural networks treatment to meteorological time-series data sets, recorded during 1991–2000 at certain Greek locations, in order to create fully appropriate solar data information. Neural networks, in this case, are used for creating missing mean, maximum and minimum global and diffuse solar irradiance hourly data, when educated with other known meteorological time-series hourly values. For this purpose, hourly data of air temperature, relative humidity, sunshine duration, clouds' octals, as well as local latitude are used with regard to these sites. Neural networks' education process outputs are checked against known hourly values of solar irradiance, based upon the mentioned meteorological hourly raw data necessary for this action recorded at the National Observatory of Athens, the actinometric station at the Technological Education Institute (TEI) of Piraeus, and six other locations. Selection of these sites is representative of the climatic conditions in Greece, from north to south and east to west. Following the same scheme, the produced hourly global and diffuse mean hourly solar irradiance values are in a very good agreement ($p < 0.01$) with actual measurements.

Wind energy

08/02223 Accurate numerical simulation of a high solidity Wells turbine

Torresi, M. *et al. Renewable Energy*, 2008, 33, (4), 735–747.

This paper provides an accurate description of the steady three-dimensional flow-field in a high solidity Wells turbine to be used in an oscillatory water column device for wave energy conversion. The analysis has been performed by solving numerically the incompressible Navier–Stokes equations in a non-inertial reference frame rotating with the turbine. Turbulence effects are taken into account via a Reynolds-average approach, the turbulent stresses being evaluated by means of the Spalart–Allmaras model. Using a very fine mesh, a quite good agreement with experimental data has been obtained in terms of efficiency, torque, and total pressure drop, at different flow rates. Moreover, the tip clearance has been properly modelled and the effect of the tip-gap on the turbine performance has been analysed in details.

08/02224 Analysis of wind power generation and prediction using ANN: a case study

Mabel, M. C. and Fernandez, E. *Renewable Energy*, 2008, 33, (5), 982–996.

Many developing nations, such as India have embarked upon wind energy programs for areas experiencing high average wind speeds throughout the year. One of the states in India that is actively pursuing wind power generation programs is Tamil Nadu. Within this state, Muppandal area is one of the identified regions where wind farm concentration is high. Wind energy engineers are interested in studies that aim at assessing the output of wind farms, for which, artificial intelligence techniques can be usefully adapted. The present paper attempts to apply this concept for assessment of the wind energy output of wind farms in Muppandal, Tamil Nadu (India). Field data are collected from seven wind farms at this site over a period of 3 years from April 2002 to March 2005 and used for the analysis and prediction of power generation from wind farms. The model has been developed with the help of neural network methodology. It involves three input variables – wind speed, relative humidity and generation hours and one output variable-energy output of wind farms. The modelling is done using MATLAB toolbox. The model accuracy is evaluated by comparing the simulated results with the actual measured values at the wind farms and is found to be in good agreement.

08/02225 Building energy performance: a LCA case study of kenaf-fibres insulation board

Ardente, F. *et al. Energy and Buildings*, 2008, 40, (1), 1–10.

The paper presents a life cycle assessment of a kenaf-fibre insulation board following the international standards of the ISO 14040 series. Each life-cycle step has been checked, from kenaf production and board manufacture by an Italian firm, to use and disposal. The aim is to assess the board eco-profile and to compare, on the basis of a life-cycle approach, the energy and environmental benefits and drawbacks related to its employment into a typical residential dwelling. A comparison among various insulating materials has been carried out. The study focuses also on processes and input materials which cause the main environmental impacts of the product, and points out critical issues and the life-cycle steps with the highest improvement potentials.

08/02226 Consequential environmental system analysis of expected offshore wind electricity production in Germany

Pehnt, M. *et al. Energy*, 2008, 33, (5), 747–759.

Taking advantage of offshore wind power appears to be of special significance for the climate protection plans announced by the German Federal Government. For this reason, a comprehensive system analysis of the possible CO_2 reduction including the consideration of all relevant processes has to be performed. This goal can be achieved by linking a life-cycle assessment model of offshore wind utilization with a stochastic model of the German electricity market. Such an extended life-cycle assessment shows that the CO_2 emissions from the construction and operation of wind farms are low compared with the substitution effects of fossil fuels. Additionally, in the German electricity system, offshore wind energy is the main substitute for medium-load power plants. CO_2 emissions from the modified operation and the expansion of conventional power plants reduce the CO_2 savings, but the substitution effect outweighs these emissions by one order of magnitude. The assumptions of the model, shown here to be above all CO_2 certificate prices, have a considerable influence on the figures shown due to a significant effect on the future energy mix.

08/02227 Economics of producing hydrogen as transportation fuel using offshore wind energy systems

Mathur, J. *et al. Energy Policy*, 2008, 36, (3), 1212–1222.

Over the past few years, hydrogen has been recognized as a suitable substitute for present vehicular fuels. This paper covers the economic analysis of one of the most promising hydrogen production methods – using wind energy for producing hydrogen through electrolysis of seawater – with a concentration on the Indian transport sector. The analysis provides insights about several questions such as the advantages of offshore plants over coastal installations, economics of large wind-machine clusters, and comparison of cost of producing hydrogen with competing gasoline. Robustness of results has been checked by developing several scenarios such as fast/slow learning rates for wind systems for determining future trends. Results of this analysis show that use of hydrogen for transportation is not likely to be attractive before 2012, and that too with considerable learning in wind, electrolyser and hydrogen storage technology.

08/02228 Impact of wind generation on the dispatch of the system: a fuzzy approach

Mangueira, H. H. D. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 67–72.

In this paper, the penetration of uncertainties of the wind generation systems on the conventional electric network is evaluated. Wind power sources are modelled by using fuzzy sets, as to include the wind's speed intrinsic uncertainty. The approach is based on a multi-linearized fuzzy power flow. Tests have been performed using a 16-bus real-life distribution system. Results obtained show, firstly, an interesting correlation among network topology and the spread of wind generation uncertainty; secondly, the losses have direct impact on the growth of fuzzyness; finally, the approach may be useful as assessment tool to evaluate the risk of not-accomplishment of contracts due to wind generation uncertainties. The approach can also used by the system operator in order to define the reserve necessary to guarantee the load balancing as well as an indicator of which buses are little affected by uncertainty.

08/02229 Network constrained wind integration on Vancouver Island

Maddaloni, J. D. *et al. Energy Policy*, 2008, 36, (2), 591–602.

The aim of this study is to determine the costs and carbon emissions associated with operating a hydro-dominated electricity generation system (Vancouver Island, Canada) with varying degrees of wind penetration. The focus is to match the wind resource, system demand and abilities of extant generating facilities on a temporal basis, resulting in an operating schedule that minimizes system cost over a given period. This is performed by taking the perspective of a social planner who desires to find the lowest-cost mix of new and existing generation facilities. Unlike other studies, this analysis considers variable efficiency for thermal and hydro-generators, resulting in a fuel cost that varies with respect to generator part load. Since this study and others have shown that wind power may induce a large variance on existing dispatchable generators, forcing more frequent operation at reduced part load, inclusion of increased fuel cost at part load is important when investigating wind integration as it can significantly reduce the economic benefits of utilizing low-cost wind. Results indicate that the introduction of wind power may reduce system operating costs, but this depends heavily on whether the capital cost of the wind farm is considered. For the Vancouver Island mix with its large hydro-component, operating cost was reduced by a maximum of 15% at a wind penetration of 50%, with a negligible reduction in operating cost when the wind farm capital cost was included.

08/02230 Promotion of new wind farms based on a decision support system

Ramírez-Rosado, I. J. *et al. Renewable Energy*, 2008, 33, (4), 558–566.
The integration in electric power networks of new renewable energy facilities is the final result of a complex planning process. One of the important objectives of this process is the selection of suitable geographical locations where such facilities can be built. This selection procedure can be a difficult task because of the initially opposing positions of the different agents involved in this procedure, such as, for example, investors, utilities, governmental agencies or social groups. The conflicting interest of the agents can delay or block the construction of new facilities. This paper presents a new decision support system, based on Geographic information systems, designed to overcome the problems posed by the agents and thus achieve a consensual selection of locations and overcome the problems deriving from their preliminary differing preferences. This paper presents the description of the decision support system, as well as the results obtained for two groups of agents useful for the selection of locations for the construction of new wind farms in La Rioja (Spain).

08/02231 Space and time: wind in an investment planning model

Neuhoff, K. *et al. Energy Economics*, 2008, 30, (4), 1990–2008.
Investment planning models inform investment decisions and government policies. Current models do not capture the intermittent nature of renewable energy sources, restricting the applicability of the models for high penetrations of renewables. A methodology was provided to capture spatial variation in wind output in combination with transmission constraints. The representation of wind distributions using stochastic approaches or using extensive historic data sets exceeds computational constraints for real world application. Hence the amount of input data was restricted, and use bootstrapping to illustrate the robustness of the results. For the UK power system the authors model wind deployment and the value of transmission capacity.

08/02232 Utility scale wind turbines on a grid-connected island: a feasibility study

Dua, M. *et al. Renewable Energy*, 2008, 33, (4), 712–719.
This paper analyses the technical and economic feasibility of installing utility-scale wind turbines on the Fox Islands, located 12 miles from the coast of Maine in the United States. Three locations on the islands, as well as a near offshore site, are analysed in detail as potential sites for wind turbine installations. As discussed in this work, the logistic problems of transporting and installing wind turbines on the island require innovative solutions. These include locally available amphibious vessels, which can land turbine components at suitable shallow spots on the island, self-erecting towers, which allow use of a smaller crane for installation, and a special turbine foundation suitable for the local ground conditions. In the economic analysis, in addition to standard life-cycle parameters, renewable energy credits were also included. This work concludes that the installation of sub-megawatt wind turbines on the island is logistically possible and will lead to a reduction in the cost of electricity to the customers.

Others, including economics

08/02233 A pre-feasibility case study on integrated resource planning including renewables

Yilmaz, P. *et al. Energy Policy*, 2008, 36, (3), 1223–1232.
In recent years, economical and environmental constraints force governments and energy policy decision-makers to change the prominent characteristics of the electricity markets. Accordingly, depending on local conditions on the demand side, usage of integrated resource planning approaches in conjunction with renewable technologies has gained more importance. In this respect, an integrated resource planning option, which includes the design and optimization of grid-connected renewable energy plants, should be evaluated to facilitate a cost-effective and green solution to a sustainable future. In this paper, an integrated resource planning case is studied for an educational campus, located in Gebze, Turkey. It is found that for the considered campus, the integrated resource planning scenario that includes renewables as a supply-side option with existing time-of-use tariff may provide a cost-effective energy production, particularly for the high penetration level of the renewables.

08/02234 A real options evaluation model for the diffusion prospects of new renewable power generation technologies

Kumbaroglu, G. *et al. Energy Economics*, 2008, 30, (4), 1882–1908.
This study presents a policy planning model that integrates learning curve information on renewable power generation technologies into a dynamic programming formulation featuring real options analysis. The model recursively evaluates a set of investment alternatives on a year-by-year basis, thereby taking into account that the flexibility to delay an irreversible investment expenditure can profoundly affect the diffusion prospects of renewable power generation technologies. Price uncertainty is introduced through stochastic processes for the average wholesale price of electricity and for input fuel prices. Demand for electricity is assumed to be increasingly price-sensitive, as the electricity market deregulation proceeds, reflecting new options of consumers to react to electricity price changes (such as time-of-use pricing, unbundled electricity services, and choice of supplier). The empirical analysis is based on data for the Turkish electricity supply industry. Apart from general implications for policy-making, it provides some interesting insights about the impact of uncertainty and technical change on the diffusion of various emerging renewable energy technologies.

08/02235 A sensitivity analysis for the design of small-scale hydropower plant: Kayabogazi case study

Aslan, Y. *et al. Renewable Energy*, 2008, 33, (4), 791–801.
In this study, the feasibility of hydroelectric power generation from the Kayabogazi dam, which was built by the State Hydraulic Works of Turkey (DSI) in 1987 in the town of Tavsanli, Kutahya, for irrigation and flood control purposes is investigated. Since a certain amount of water is supplied from the dam to the town of Tavsanli as drinking water, that amount is deducted from the total and is not allowed to be used in the process of electric power generation. By evaluating the amount of incoming water to the Kayabogazi dam in the period of 1995 and 2003 years, the most agreeable turbine type and size is decided for a small hydropower plant (SHP). In this purpose, seven different cases have been taken into consideration. As a conclusion, the case used three turbines which one of them is installed to utilize from the higher flow rates has been determined as the best configuration. In this study, a power generation ranging between 0.313 and 4.997 MW has been achieved in the viewpoint of installed capacity for Kayabogazi dam. Hence, it has been estimated an electricity generation up to 10,579 MWh per annum.

08/02236 An adopter-centric approach to analyze the diffusion patterns of innovative residential heating systems in Sweden

Mahapatra, K. and Gustavsson, L. *Energy Policy*, 2008, 36, (2), 577–590.
Innovation and diffusion of renewable energy technologies play a major role in mitigation of climate change. In Sweden replacing electric and oil heating systems with innovative heating systems such as district heating, heat pumps and wood pellet boilers in detached homes is a significant mitigation option. Using an adopter-centric approach, the authors analysed the influence of investment subsidy on conversion of resistance heaters and oil boilers, and the variation in diffusion pattern of district heating, heat pumps and pellet boilers in Swedish detached homes. Results from questionnaire surveys of 1500 randomly selected homeowners in September 2004 and January 2007 showed that more than 80% of the respondents did not intend to install a new heating system. Hence, about 37% of the homeowners still have electric and oil heating systems. The government investment subsidy was important for conversion from a resistance heater, but not from an oil boiler. This is

because homeowners currently replacing their oil boilers are the laggards, while those replacing resistance heaters are the 'early adopters'. Economic aspects and functional reliability were the most important factors for the homeowners when considering a new heating system. There is a variation in the perceived advantages associated with each of the innovative heating systems and therefore, the diffusion patterns of such systems vary. Installers and interpersonal sources were the most important communication channels for information on heating systems.

08/02237 An econometric study on long-term energy outlook and the implications of renewable energy utilization in Malaysia

Gan, P. Y. and Li, Z. D. *Energy Policy*, 2008, 36, (2), 890–899.

A comprehensive econometric model was developed to study the long-term outlook of Malaysia's economy, energy and environment to 2030. The projections under the reference scenario indicated that Malaysia's gross domestic production (GDP) is expected to average 4.6% from 2004 to 2030, and total primary energy consumption will triple by 2030. Coal import will increase following governmental policy of intensifying its use for power generation. Oil import is predicted to take place by 2013 and reach 45 Mtoe in 2030. Hence, in the near future, Malaysia's energy import dependency will rise. Carbon emissions will triple by 2030. On the other hand, the projections under an alternative renewable energy (RE) scenario showed that the utilization of RE is a strategic option to improve the long-term energy security and environmental performance of Malaysia. However, substantial governmental involvements and support, as well as the establishment of a regulatory framework are necessary.

08/02238 An integrated assessment of a large-scale biodiesel production in Italy: killing several birds with one stone?

Russi, D. *Energy Policy*, 2008, 36, (3), 1168–1180.

Biofuels are often presented as a contribution towards the solution of the problems related to our strong dependency on fossil fuels, i.e. greenhouse effect, energy dependency, urban pollution, besides being a way to support rural development. In this paper, an integrated assessment approach is employed to discuss the social desirability of a large-scale biodiesel production in Italy, taking into account social, environmental and economic factors. The conclusion is that the advantages in terms of reduction of greenhouse gas emissions, energy dependency and urban pollution would be very modest. The small benefits would not be enough to offset the huge costs in terms of land requirement: if the target of the European Directive 2003/30/EC were reached (5.75% of the energy used for transport by 2010) the equivalent of about one-third of the Italian agricultural land would be needed. The consequences would be a considerable increase in food imports and large environmental impacts in the agricultural phase. Also, since biodiesel must be de-taxed in order to make it competitive with oil-derived diesel, the Italian energy revenues would be reduced. In the end, rural development remains the only sound reason to promote biodiesel, but even for this objective other strategies look more advisable, like supporting organic agriculture.

08/02239 Application of fluid–structure interaction simulation of an ocean wave energy extraction device

Agamloh, E. B. *et al. Renewable Energy*, 2008, 33, (4), 748–757.

A numerical technique that employs a computational fluid dynamics code is used to perform coupled fluid–structure interaction simulation of a wave energy device in order to assess power output in a 3D numerical wave flume. The current method determines the motion of the buoy from the dynamic solution of the fluid flow problem and the dynamic buoy motion problem rather than prescribing the motion of the buoy. The power output of the device is calculated for different wave conditions. The technique was expanded for an array of two buoys to determine the interference between them.

08/02240 Community renewable energy: what should it mean?

Walker, G. and Devine-Wright, P. *Energy Policy*, 2008, 36, (2), 497–500.

Community is a much used word that is readily attached to projects, initiatives and policies as part of the discursive politics of modern governance. This paper considers the way in which community has become attached to renewable energy projects in the UK, both in grassroot action and in mainstream energy policy. The authors ask what those involved have seen as distinctive about community renewable energy projects that makes them different from other renewable energy installations. The study aims to identify a diversity of understandings and interpretations that revolve around questions of both process (who the project is by) and outcome (who the project is for). The implications of this are then evaluated, identifying the importance of the process of project development for realizing the catalytic and learning effects of meaningful and substantial local involvement.

08/02241 Containerized handling to minimize hauling cost of herbaceous biomass

Cundiff, J. S. and Grisso, R. D. *Biomass and Bioenergy*, 2008, 32, (4), 308–313.

Herbaceous biomass can contribute to the renewable energy supply for electricity, process steam, liquid fuel, and commodity chemicals. Efficient systems to harvest and store round bales of perennial grass in storage locations within 5 km of the production fields are available. The major limitations are loading these bales at the storage locations and hauling to meet a weekly demand schedule at a processing plant operating continuously for 50 weeks year^{-1}. Analysis is presented for a 27 Mg h^{-1} plant. The concept is to pack 32, 1.5-m round bales into a container with the same dimensions as a 12.2-m (40-ft) ISO shipping container. These containers are loaded at a satellite storage location, hauled to a receiving facility at the processing plant, and unloaded. The analysis examines two options. Option 1 uses a forklift to place a loaded container onto a standard transport chassis at the satellite storage location. A similar forklift unloads the containers at the receiving facility. Option 2 uses a Swinglift trailer that loads and unloads the containers onto the trailer using on-board hydraulics. The cost for Option 1 was calculated at $7.80 dry Mg^{-1}, as compared with $8.37 dry Mg^{-1} calculated for Option 2. The cost for Option 1 is lower even though the forklift used at the satellite storage location in Option 1 is only operated at 27% of daily capacity, thus operating cost per dry Mg to load is higher than it would be if scheduling could be done such that more containers could be loaded each workday. The forklift spends most of the time waiting for the container to be packed with bales. The limiting factor established in this analysis is the feasibility of packing 32 bales into a container within an allowed 30 min.

08/02242 Costs of producing miscanthus and switchgrass for bioenergy in Illinois

Khanna, M. *et al. Biomass and Bioenergy*, 2008, 32, (6), 482–493.

There is growing interest in using perennial grasses as renewable fuels for generating electricity and for producing bio-ethanol. This paper examines the costs of producing two bioenergy crops, switchgrass and miscanthus, in Illinois for co-firing with coal to generate electricity. A crop-productivity model, MISCANMOD, is used together with a GIS to estimate yields of miscanthus across counties in Illinois. Spatially variable yields, together with county-specific opportunity costs of land, are used to determine the spatial variability in the breakeven farm-gate price of miscanthus. Costs of transporting bioenergy crops to the nearest existing power plant are incorporated to obtain delivered costs of bioenergy. The breakeven delivered cost of miscanthus for an average yield of 35.76 t ha^{-1} in Illinois is found to be less than two-thirds of the breakeven price of switchgrass with an average yield of 9.4 t ha^{-1}. There is considerable spatial variability in the breakeven farm-gate price of miscanthus, which ranges between 41 and 58 $ t^{-1} across the various counties in Illinois. This together with differences in the distances miscanthus has to be shipped to the nearest power plant causes variability in the costs of using bioenergy to produce electricity. The breakeven cost of bioenergy for electricity generation ranges from 44 to 80 $ t^{-1} DM and is considerably higher than the coal energy-equivalent biomass price of 20.22 $ t^{-1} DM that power plants in Illinois might be willing to pay. These findings imply a need for policies that will provide incentives for producing and using bioenergy crops based on their environmental benefits in addition to their energy content.

08/02243 Designing cost-effective seawater reverse osmosis system under optimal energy options

Gilau, A. M. and Small, M. J. *Renewable Energy*, 2008, 33, (4), 617–630.

Today, three billion people around the world have no access to clean drinking water and about 1.76 billion people live in areas already facing a high degree of water stress. This paper analyses the cost-effectiveness of a stand alone small-scale renewable energy-powered seawater reverse osmosis (SWRO) system for developing countries. In this paper, a new methodology has been introduced; an energy optimization model which simulates hourly power production from renewable energy sources. Applying the model using the wind and solar radiation conditions for Eritrea, East Africa, the authors computed hourly water production for a two-stage SWRO system with a capacity of 35 m^3/day. According to the results, specific energy consumption is about 2.33 kW h/m^3, which is a lower value than that achieved in most of the previous designs. The use of a booster pump, energy recovery turbine and an appropriate membrane, allows the specific energy consumption to be decreased by about 70% compared to less efficient design without these features. The energy recovery turbine results in a reduction in the water cost of about 41%. The results show that a wind-powered system is the least cost and a PV-powered system the most expensive, with finished water costs of about 0.50 and 1.00$/m^3, respectively. By international standards, for example, in China, these values are considered economically feasible. Detailed simulations of the RO system design, energy options, and power, water, and life-cycle costs are presented.

08/02244 Energy and exergy analysis of a latent heat storage system with phase change material for a solar collector

Koca, A. *et al. Renewable Energy*, 2008, 33, (4), 567–574.

Analysis of energy and exergy has been performed for a latent heat storage system with phase change material (PCM) for a flat-plate solar collector. $CaCl_2{\cdot}6H_2O$ was used as PCM in thermal energy storage (TES) system. The designed collector combines in single unit solar energy collection and storage. PCMs are stored in a storage tank, which is located under the collector. A special heat transfer fluid was used to transfer heat from collector to PCM. Exergy analysis, which is based on the second law of thermodynamics, and energy analysis, which is based on the first law, were applied for evaluation of the system efficiency for charging period. The analyses were performed on 3 days in October. It was observed that the average net energy and exergy efficiencies are 45% and 2.2%, respectively.

08/02245 Energy performance of wood-burning cookstoves in Michoacan, Mexico

Berrueta, W. M. *et al. Renewable Energy*, 2008, 33, (5), 859–870.

There have been few detailed assessments of the actual impacts of improved stove interventions in rural communities, although many improved stove projects have reported overall efficiencies from tests in simulated kitchens using water-boiling tests (WBTs). This paper presents an integrated energy evaluation of the Patsari cookstove, an efficient wood-burning cookstove developed in Mexico that has recently obtained international recognition, in comparison to traditional cookstoves in rural communities of Michoacan, Mexico. The evaluation uses three standard protocols: the WBT, which quantifies thermal efficiency and firepower; the controlled cooking test (CCT), which measures specific energy consumption associated with local cooking tasks, and the kitchen performance test, which evaluates the behaviour of the stoves in-field conditions and estimates fuel savings. The results showed that the WBT gave little indication of the overall performance of the stove in rural communities. Field testing in rural communities is of critical importance, therefore, in estimating the benefits of improved stoves. In the CCT for tortilla making, the main cooking task in Mexican rural households, Patsari stoves showed fuelwood savings ranging from 44% to 65% in relation to traditional open fires ($n=6$; $P<0.05$). These savings were similar in magnitude to the average energy savings from KPT before and after Patsari adoption of 67% ($n=23$; $P<0.05$) in rural households exclusively using fuelwood. Similar energy savings of 66% for fuelwood and 64% for LPG, respectively, were also observed in households using mixed fuels. With sound technical design, critical input from local users and proper dissemination strategies, therefore, improved stoves can significantly contribute to improvements in the quality of life of rural people with potential benefits to the surrounding environment.

08/02246 'Energy Tower' combined with pumped storage and desalination: optimal design and analysis

Omer, E. *et al. Renewable Energy*, 2008, 33, (4), 597–607.

The 'energy tower' (ET) is a power plant project that uses hot dry air and seawater to produce electricity. An optimized design of a system that is a combination of an ET, pumped storage and seawater desalination plant is considered. A model set covering each subsystem, and results of the optimized design for a project in the area of Eilat are presented. The additional benefit from combining the systems comes from an efficient use of the energy in the brine water coming from the desalination process, and from using pumped storage in an unconventional way. The benefits of the combined system lead to an increase of 14% in the annual net profit, compared to the sum of profits from optimally designed stand-alone systems.

08/02247 Enhanced merit order and augmented Lagrange Hopfield network for hydrothermal scheduling

Dieu, V. N. and Ongsakul, W. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (2), 93–101.

This paper proposes an enhanced merit order (EMO) and augmented Lagrange Hopfield network (ALHN) for solving hydrothermal scheduling (HTS) problem with pumped-storage units. EMO is a merit order enhanced by heuristic search based algorithms and the ALHN is a continuous Hopfield network with its energy function based on augmented Lagrangian function. EMO is efficient in unit scheduling, whereas ALHN can properly handle generation ramp rate limits, and time coupling constraints such as limited fuel, water discharge for hydro units, and water balance for pumped-storage units. The proposed method solves HTS problem by optimizing step by step of sub-problems in four phases. In the first phase, EMO is applied to solve only thermal unit commitment satisfying power balance, spinning reserve, limited fuel, and minimum up and down time constraints. In the second phase, the enhanced ALHN is used to solve economic dispatch (ED) and commit hydro units based on the obtained unit schedule from the first phase. In the third phase, the enhanced ALHN is applied to handle transmission constraint. In the last phase, the enhanced ALHN is used to commit pumped-storage units and solve final constrained ED. In each phase, heuristic search based algorithms are applied to repair the constraint violations and refine the obtained solution. The proposed EMO–ALHN is tested on a hydrothermal system with 17 thermal, two hydro, and two pumped-storage hydro units with a scheduling time horizon of 24 h. Test results indicate that the proposed method obtains less costs and faster computational times than those from augmented Hopfield neural network (AHN) and hybrid enhanced Lagrangian relaxation and quadratic programming (Hybrid LRQP) for two test cases.

08/02248 Experimental characterisation of a thermal energy storage system using temperature and power controlled charging

Mawire, A. and McPherson, M. *Renewable Energy*, 2008, 33, (4), 682–693.

The experimental set-up and technical aspects for charging a thermal energy storage (TES) of a proposed solar cooker at constant temperature and variable electrical power are presented. The TES is developed using a packed pebble bed. An electrical hot plate simulates the concentrator which heats up oil circulating through a copper coil absorber charging the TES system. A computer program to acquire data for monitoring the storage system and to maintain a nearly constant outlet charging temperature is developed using visual basic. The input power to the hot plate is also controlled to simulate the variation of the daily solar radiation by using another visual basic program. A combined internal model control and proportional, integral and derivative temperature control structure is tested on the TES system under varying conditions and its performance is reasonable within a few degrees of the set temperature points. Results of the charging experiments are used to characterize the storage system. The different experiments indicate various degrees of stratification in the storage tank.

08/02249 GIS-based approach for defining bioenergy facilities location: a case study in Northern Spain based on marginal delivery costs and resources competition between facilities

Panichelli, L. and Gnansounou, E. *Biomass and Bioenergy*, 2008, 32, (4), 289–300.

This paper presents a geographical information system (GIS)-based decision support system for selecting least-cost bioenergy locations when there is a significant variability in biomass farmgate price and when more than one bioenergy plant with a fixed capacity has to be placed in the region. The methodology tackles the resources competition problem between energy facilities through a location-allocation model based on least-cost biomass quantities. Whole system least delivery cost including intermediate bioenergy products is estimated. The methodology is based on a case study where forest wood residues (FWR) from final cuttings are used to produce torrefied wood (TW) in two torrefaction plants (TUs) that supply a gasification unit (GU) in order to produce electricity. The provinces of Navarra, Bizkaia, Gipuzkoa, Alava, La Rioja, Cantabria and Burgos are assessed in order to find the best locations for settling down the TUs and the GU according to biomass availability, FWR and TW marginal delivery costs.

08/02250 Optimising power generation efficiency for head-sensitive cascaded reservoirs in a competitive electricity market

Mariano, S. J. P. S. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (2), 125–133.

This paper is on the problem of short-term hydro scheduling (STHS), particularly concerning head-sensitive reservoirs under competitive environment. The authors propose a novel method, based on non-linear programming (NLP), for optimizing power generation efficiency. This method considers hydroelectric power generation as a non-linear function of water discharge and of the head. The main contribution of this paper is that the maximum water discharge, thus giving the maximum power generation, is also considered as head-dependent in order to obtain more realistic and feasible results. The proposed method has been applied successfully to solve a case study based on one of the Portuguese cascaded hydro systems, providing a higher profit at an acceptable computation time in comparison with classical optimization methods based on linear programming (LP) that ignore head dependence.

08/02251 Reservoir management at Awibengkok geothermal field, West Java, Indonesia

Acuña, J. A. *et al. Geothermics*, 2008, 37, (3), 332–346.

The Awibengkok geothermal field, also known as Salak, is the largest developed geothermal resource in Indonesia, currently sustaining 377 MW of electrical generation. It is a water-dominated, naturally fractured reservoir with benign fluid chemistry. A very large amount of produced brine is injected along the margins of the proven reservoir.

After 13 years of continuous operation, production levels have been maintained at or above nominal turbine capacity through periodic make-up drilling and field management. The two main challenges have been taking advantage of the changing reservoir thermodynamic conditions and managing injection. Some innovations in well design and drilling procedures include sizing up the production casing from tie-backs, and drilling shallow, relatively high-angle (55–60° inclination) wells to maximize production from the steam cap. Well deliverability predictions have been improved by combining well production history and downhole measurements to construct wellbore hydraulic models. Changes in injection strategy were made periodically to optimize heat recovery based on well performance and trends in well chloride concentration and enthalpy. Thermally stable tracers have been used to better understand inter-well connectivity. Make-up drilling has been managed to take advantage of evolving thermodynamic conditions in different parts of the field. Reservoir management has required continuously adapting production and injection strategies in response to reservoir evolution. This is only possible through maintaining robust data gathering and monitoring programs. Efforts are currently underway to evaluate expanding the area of production by moving injection deeper or to more distal locations.

08/02252 Technical and economic assessment of hybrid photovoltaic/wind system with battery storage in Corsica island

Diaf, S. *et al. Energy Policy*, 2008, 36, (2), 743–754.

The sizing and techno-economical optimization of a stand-alone hybrid photovoltaic/wind system (HPWS) with battery storage is presented in this paper. The main objective of the present study is to find the optimum size of system, able to fulfill the energy requirements of a given load distribution, for three sites located at Corsica island and to analyse the impact of different parameters on the system size. The methodology used provides a useful and simple approach for sizing and analysing an HPWS. In the proposed stand-alone system, a new concept such as the supply of wind power via a uninterruptible power supply (UPS) is introduced and therefore the energy produced by the wind generator can be sent directly to the load. In this context, an optimization sizing model is developed. It consists of three submodels; system components submodels, technical submodel based on the loss of power supply probability (LPSP) and the economical submodel based on the levelized cost of energy (LCE). Applying the developed model, configurations meeting the desired LPSP are obtained. The configuration with the lowest LCE gives the optimal one. Analysing the optimal system configurations used to satisfy the requirements of typical residential home (3 kWh/day), a significant reduction in system size is observed as the available renewable potential increases leading to a considerable decrease in LCE (case of Cape corse site). The 2 days storage capacity is found to be the best for the optimal configuration with the lowest LCE. On the other hand, for low energy requirements, the LCE is found relatively high and decreases sharply with the increase in load. However, for low LPSP values, the LCE is found to rise sharply for a little increase in LPSP.

08/02253 The economics of wind power with energy storage

Benitez, L. *et al. Energy Economics*, 2008, 30, (4), 1973–1989.

In this paper, a non-linear mathematical optimization program is developed for investigating the economic and environmental implications of wind penetration in electrical grids and evaluating how hydropower storage could be used to offset wind power intermittence. When wind power is added to an electrical grid consisting of thermal and hydropower plants, it increases system variability and results in a need for additional peak-load, gas-fired generators. The empirical application using load data for Alberta's electrical grid shows that costs of wind-generated electricity vary from $37 per MWh to $68/MWh, and depend primarily on the wind profiles of installed turbines. Costs of reducing CO_2 emissions are estimated to be $41–$56 per t CO_2. When pumped hydro storage is introduced in the system or the capacity of the water reservoirs is enhanced, the hydropower facility could provide most of the peak load requirements obviating the need to build large peak-load gas generators.

08/02254 The prediction of the hydrodynamic performance of marine current turbines

Batten, W M. J. *et al. Renewable Energy*, 2008, 33, (5), 1085–1096.

The development of a blade element momentum (BEM) model for the hydrodynamic design of marine current turbines is presented. The model includes routines for interpolation of 2D section data and extrapolation for stall delay. The numerical model is compared with experimental data obtained from tests of an 800 mm diameter model rotor carried out in a cavitation tunnel. The theoretical predictions are in good agreement with the experiments. Using this validated model, a typical 3D rotor is used to demonstrate parametric variations of the design parameters. The effect of tip immersion on possible cavitation is assessed for this rotor. The model is then used to solve the dynamic effects of a tidal profile. The effect of an increase in blade roughness is presented, indicating a relatively small reduction in power. This work demonstrates that the numerical model developed can provide a useful tool for the investigation of the hydrodynamic design and operation of marine current turbines.

08/02255 Thermodynamic analysis of aqueous-reforming of polylols for hydrogen generation

Luo, L. *et al. Fuel*, 2007, 86, (12–13), 1727–1736.

This paper aims to study the thermodynamic features of polylols reforming to generate hydrogen gas. Polylols can be converted into carbon dioxide and hydrogen via aqueous reforming with co-existence of low level of carbon monoxide due to reverse water-gas-shift (R-WGS) reaction and subsequently, CO and/or CO_2 and H_2 react to form CH_4 via side reaction of methanation. Here Matlab language is employed to calculate the reaction heat, equilibrium constant and equilibrium molar fraction of each component through solving the non-linear equations. The calculation results suggest that the polylol reforming reaction is endothermic and but should be carried at low temperature to give very low level of CO content (dry basis) in the gas production. The results also demonstrate that low temperature favors the methanation, which should be limited kinetically during the operation. In addition, choosing system pressure slightly higher than the saturation water pressure is unfavorable to the R-WGS reaction but favorable to the low level of CO content, desirably.

14 FUEL SCIENCE AND TECHNOLOGY

Fundamental science, analysis, instrumentation

08/02256 A correlation for calculating elemental composition from proximate analysis of biomass materials

Parikh, J. *et al. Fuel*, 2007, 86, (12–13), 1710–1719.

Elemental composition of biomass is an important property, which defines the energy content and determines the clean and efficient use of the biomass materials. However, the ultimate analysis requires very expensive equipments and highly trained analysts. The proximate analysis on the other hand only requires standard laboratory equipments and can be run by any competent scientist or engineer. This work introduces a general correlation, based on proximate analysis of biomass materials, to calculate elemental composition, derived using 200 data points and validated further for additional 50 data points. The entire spectrum of solid lignocellulosic materials have been considered in the derivation of the present correlation, which is given as: $C = 0.637FC + 0.455VM$, $H = 0.052FC + 0.062VM$, $O = 0.304FC + 0.476VM$, where FC – 4.7–38.4% fixed carbon, VM – 57.2–90.6% volatile matter, C – 36.2–53.1% carbon, H – 4.36–8.3% hydrogen and O – 31.37–49.5% oxygen in wt% on a dry basis. The average absolute error of these correlations are 3.21%, 4.79%, 3.4% and bias error of 0.21%, –0.15% and 0.49% with respect to measured values C, H and O, respectively. The major advantage of these correlations is their capability to compute elemental components of biomass materials from the simple proximate analysis and thereby provides a useful tool for the modelling of combustion, gasification and pyrolysis processes.

08/02257 A game-theoretic model for electricity markets with tight capacity constraints

Hu, Z. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (3), 207–215.

In this paper, an artificial neural network model for short-term price forecasting and a linear regression model for mid/long-term price forecasting are described together with forecasting results. A detailed discussion on the choice of forecast models and forecast variables is reported. The suggested methods are being utilized by the transmission company to forecast short-term and mid/long-term prices in the Zhejiang electricity market. The results show that the proposed forecast models meet the basic requirement of Zhejiang electricity market operation. A second objective of this work is to present the results of a series of experiments designed to justify certain game-theoretic assertions and to explain the price volatility experienced in many real-world markets under uniform pricing and pay-as-bid pricing.

08/02258 A generalised stochastic model for the simulation of occupant presence

Page, J. *et al. Energy and Buildings*, 2008, 40, (2), 83–98.

This paper describes an algorithm for the simulation of occupant presence, to be later used as an input for future occupant behaviour models within building simulation tools. By considering occupant presence as an inhomogeneous Markov chain interrupted by occasional periods of long absence, the model generates a time series of the state of presence (absent or present) of each occupant of a zone, for each zone of any number of buildings. Tested on occupancy data from private offices, the model has proven its capacity to realistically reproduce key properties of occupant presence such as times of arrival and departure, periods of intermediate absence and presence as well as periods of long absence from the zone. This model (due to related metabolic heat gains), and associated behavioural models which use occupants' presence as an input, have direct consequences for building energy consumption.

08/02259 A hybrid genetic algorithm approach based on differential evolution for economic dispatch with valve-point effect

He, D. *et al. International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 31–38.

An efficient hybrid genetic algorithm (HGA) approach for solving the economic dispatch problem (EDP) with valve-point effect is presented in this paper. The proposed method combines the GA algorithm with the differential evolution (DE) and sequential quadratic programming (SQP) technique to improve the performance of the algorithm. GA is the main optimizer, while the DE and SQP are used to fine tune in the solution of the GA run. To improve the performance of the SQP, the cost function of EDP is approximated by using a smooth and differentiable function based on the maximum entropy principle. An initial population obtained by using uniform design exerts optimal performance of the proposed hybrid algorithm. The combined algorithm is validated for two test systems consisting of 13 and 40 thermal units whose incremental fuel cost function takes into account the valve-point loading effects. The proposed combined method outperforms other algorithms reported in literatures (EP, EP–SQP, PSO, PSO–SQP) for EDP considering valve-point effects.

08/02260 A linearized model for estimating the performance of submerged resonant wave energy converters

Filianoti, P. and Camporeale, S. M. *Renewable Energy*, 2008, 33, (4), 631–641.

A realistic performance analysis of oscillating water column wave energy converters (WECs) addresses to a set of non-linear differential equations that need to be integrated in time, by using a stochastic approach, under the hypothesis of random wind-generated sea waves, for all the sea states which characterize the location of the system. Non-linearities of the differential equations have several origins: minor and major losses of the unsteady flow of water and air; compressibility of air and heat exchange with the walls of the air chamber; and non-linear characteristics of the turbine. Under the hypothesis of random sea waves with Gaussian distribution, the authors propose an original methodology for linearizing the differential equations that describe the flow motion inside a wholly submerged WEC. Under such hypothesis, the linearized model can be used for predicting the power output by means of the calculations in the frequency domain and for control design. The developed methodology has been applied to the estimation of the performance of the new 'resonant sea wave energy converters', called REWEC, patented by Boccotti in 1998, and consisting of several caissons, characterized by a structure similar to the caissons of the traditional breakwaters and placed on the seabed, close one to each other, to form a submerged breakwater. Each caisson is connected to a vertical duct wholly beneath the sea level, where a hydraulic Wells turbine is placed. The matching between turbine and resonance characteristic of the system is carefully analysed in order to maximize the energy conversion efficiency. Some results, given for a small installation in the Mediterranean sea, confirm that the REWEC system is able to absorb a large share of the incident wave energy due to a very simple regulation system which permits the tuning on sea states with different significant heights.

08/02261 A new model to evaluate the dynamic adaptation of an electric distribution system

Garcia, E. *et al. Energy Economics*, 2008, 30, (4), 1648–1658.

The main objective of this paper is to present a model developed to evaluate the dynamic adaptation of an electric energy distribution system respecting its planning for a given period of tariff control. The model is based on a two-stage strategy that deals with the mid/short-term and long term planning, respectively. The starting point for modelling is brought about by the results from a multi-attribute method based on fuzzy dynamic programming and on analytic hierarchy processes for a mid/short-term horizon. Such a method produces a set of possible evolution trajectories which can be defined as satisfactory when they evolve above a given risk threshold that the planner is willing to accept. Then, the decision-making activities within the framework of the analytic hierarchy processes are those tasks that allow defining a vector for dynamic adaptation of the system, which is directly associated to an eventual series of imbalances that take place during its evolution.

08/02262 A new termination control method for a clothes drying process in a clothes dryer

Ng, A. B. and Deng, S. *Applied Energy*, 2008, 85, (9), 818–829.

This paper reports on a study of developing a new termination control method for a clothes dryer, using both mathematical modeling and experimental approaches. Drying models in a constant-rate drying period and a falling-rate drying period were developed, based on well-established drying theory and using a 'semi-empirical' approach. Drying experiments with regard to drying of cotton fabrics in different drying environments were carried out. A new termination control method using the equilibrium moisture content in ambient environment as a termination point has been investigated. The effectiveness of this new method has been evaluated by both experimental and modelling approaches. The results of the evaluation have demonstrated that the new method is workable and can help achieve energy saving.

08/02263 A sizing method for stand-alone PV installations with variable demand

Posadillo, R. and Luque, R. L. *Renewable Energy*, 2008, 33, (5), 1049–1055.

The practical applicability of the considerations made in a previous paper to characterize energy balances in stand-alone photovoltaic systems (SAPV) is presented. Given that energy balances were characterized based on monthly estimations, the method is appropriate for sizing installations with variable monthly demands and variable monthly panel tilt (for seasonal estimations). The method presented is original in that it is the only method proposed for this type of demand. The method is based on the rational utilization of daily solar radiation distribution functions. When exact mathematical expressions are not available, approximate empirical expressions can be used. The more precise the statistical characterization of the solar radiation on the receiver module, the more precise the sizing method given that the characterization will solely depend on the distribution function of the daily global irradiation on the tilted surface $H_{g\beta i}$. This method, like previous ones, uses the concept of loss of load probability (LLP) as a parameter to characterize system design and includes information on the standard deviation of this parameter (σ_{LLP}) as well as two new parameters: annual number of system failures (f) and the standard deviation of annual number of system failures (σ_f). This paper therefore provides an analytical method for evaluating and sizing stand-alone PV systems with variable monthly demand and panel inclination. The sizing method has also been applied in a practical manner.

08/02264 A three-phase power flow algorithm for distribution system power flow based on loop-analysis method

Wu, W. C. and Zhang, B. M. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 8–15.

Based on loop-analysis method, a theoretical formulation of the forward/backward sweep with compensation power flow method is presented. The reason, why the convergence of this widely used method deteriorates when the network becomes more meshed, is also well analysed. Subsequently, a novel solution of unbalanced three-phase power systems based on loop-analysis method is developed in this paper. The convergence speed of this algorithm remains very well even when network become more meshed. Furthermore, the implementation of this algorithm is similar with that of the forward/backward sweep with compensation method with the characteristic of understandability. This proposed method has clear theory foundation and takes full advantage of the radial (or weakly meshed) structure of distribution systems. The numerical test proves this new method is very robust and has excellent convergence characteristics.

08/02265 Approaches for developing a sizing method for stand-alone PV systems with variable demand

Posadillo, R. and Luque, R. L. *Renewable Energy*, 2008, 33, (5), 1037–1048.

Accurate sizing is one of the most important aspects to take into consideration when designing a stand-alone photovoltaic system (SAPV). Various methods, which differ in terms of their simplicity or reliability, have been developed for this purpose. Analytical methods, which seek functional relationships between variables of interest to the sizing problem, are one of these approaches. A series of rational considerations are presented in this paper with the aim of shedding light upon the basic principles and results of various sizing methods proposed by different authors. These considerations set the basis for a new analytical method that has been designed for systems with variable monthly energy demands. Following previous approaches, the method proposed is based on the concept of loss of load probability (LLP) – a parameter that is used to characterize system design. The method includes information on the standard deviation of loss of load probability (σ_{LLP}) and on two new parameters: annual number of system failures (f) and standard deviation of annual number of failures (σ_f).The method proves useful for sizing a PV system in a reliable manner and serves to explain the discrepancies found in the research on systems with $\mathrm{LLP} < 10^{-2}$. It is demonstrated that reliability depends not only on the sizing variables and on the distribution function of solar radiation, but on the minimum value as well, which in a given location and with a monthly average clearness index, achieves total solar radiation on the receiver surface.

08/02266 Computational fluid dynamic simulations in thermal waste treatment technology – design, optimisation and troubleshooting

Hájek, J. *Energy*, 2008, 33, (6), 930–941.

The present work provides three case studies featuring applications of computational fluid dynamics (CFD) in the area of thermal waste treatment (TWT). The paper demonstrates the benefits offered by simulations in TWT technology in the design, optimization and troubleshooting of those systems. The case studies deal with practical problems, namely a performance evaluation of a fabric filter bag with an add-on Venturi nozzle, the design optimization of flow homogenizing vanes in a heat exchanger, and finally troubleshooting in a novel volatile organic compound treatment unit. Each case study includes an outline of the modelling approach and summary of the most important results. The flow analyses are performed using standard methods implemented in the commercial software code FLUENT. The case study on design optimization combines decision support in the selection of the best conceptual solution and an automatic shape optimization using the commercial code SCULPTOR. The results clearly show the usefulness and applicability of the CFD computations in the area of thermal waste treatment.

08/02267 Creep constitutive equation of dual phase 9Cr-ODS steel

Sakasegawa, H. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 82–89.

9Cr-ODS (oxide dispersion strengthened) steels developed by Japan Atomic Energy Agency (JAEA) have superior creep properties compared with conventional heat resistant steels. The ODS steels can enormously contribute to practical applications of fast breeder reactors and more attractive fusion reactors. Key issues are developments of material processing procedures for mass production and creep life prediction methods in present R&D. In this study, formulation of creep constitutive equation was performed against the backdrop. The 9Cr-ODS steel displaying an excellent creep property is a dual phase steel. The ODS steel is strengthened by the δ ferrite which has a finer dispersion of oxide particles and shows a higher hardness than the *′-martensite. The δ ferrite functions as a reinforcement in the dual phase 9Cr-ODS steel. Its creep behaviour is very unique and cannot be interpreted by conventional theories of heat resistant steels. Alternative qualitative model of creep mechanism was formulated at the start of this study using the results of microstructural observations. Based on the alternative creep mechanism model, a novel creep constitutive equation was formulated using the exponential type creep equation extended by a law of mixture.

08/02268 Detailed kinetic models for catalytic reforming

Wei, W. *et al. Fuel Processing Technology*, 2008, 89, (4), 344–349.

Catalyst reforming was used as a ‘vehicle’ process chemistry to validate a set of tools for the automated construction of kinetic models. This is because the catalytic reforming process exposes many important modelling concepts and features, including multiple reaction families, catalyst deactivation, temperature profiling, parameter optimization, recycling, etc. A previously published reforming reaction network was built and customized using the Kinetic Model Editor (KME) software, which includes a standard model library, a model code generator (CodeGen) and an Excel-based graphical user interface. Modelled features, which included catalyst deactivation, serial reactors, energy balance, and model tuning, were conveniently implemented in the KME application. The confrontation of model results with experimental observations suggests that the model is well founded and is a good platform for additional process-specific refinements.

08/02269 Dynamic economic emission dispatch using nondominated sorting genetic algorithm-II

Basu, M. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (2), 140–149.

This paper presents non-dominated sorting genetic algorithm-II for a dynamic economic emission dispatch problem. This problem is formulated as a non-linear constrained multi-objective optimization problem. Non-dominated sorting genetic algorithm-II is proposed to handle dynamic economic emission dispatch problem as a true multi-objective optimization problem with competing and non-commensurable objectives. The proposed approach has a good performance in finding a diverse set of solutions and in converging near the true pareto-optimal set. Numerical results for a sample test system have been presented to demonstrate the capabilities of the proposed approach to generate well-distributed pareto-optimal solutions of dynamic economic emission dispatch problem in one single run. The comparison with the classical technique demonstrates the superiority of the proposed algorithm.

08/02270 e-Science in high energy density science research

Nishihara, K. *et al. Fusion Engineering and Design*, 2008, 83, (2–3), 525–529.

In this paper, three achievements are presented related to e-Science in high energy density science research. The authors have developed a test module of new data base system for nation-wide users of the high power lasers at Osaka University with web technology, flexible control system and XML-database, which provide efficient, accurate and flexible R&D processing. A EUV-GRID portal system was also constructed for integrated computer simulations of laser produced plasma–extreme ultraviolet (LPP–EUV) light source development, which provides flexible framework for automatic sequencing of workflow for the integrated simulations. A dynamical domain decomposition method in molecular dynamic (MD) simulations is required to obtain a good adaptive load balancing for heterogeneous computing environments such as grid. The authors developed a new algorithm of the dynamical domain decomposition. Large scale MD-message passing interface (MPI) simulations were successfully performed on cluster computers connected through Super-SINET using the National Research Grid Initiative (NAREGI GRID) grid middleware and the new algorithm.

08/02271 Effect of porous coating on two-phase pressure drop of water during up-flow boiling in tubes

Yildiz, S. *International Communications in Heat and Mass Transfer*, 2008, 35, (3), 326–337.

This paper focuses on the effects of porous coating on two-phase flow pressure drop during up-flow boiling of water in vertical tubes. The experiments were carried out under subcooled fluid–inlet conditions (5–73 K) for different mass fluxes (200–400 $\mathrm{kg/m^2 s}$) and pressures (0.11–0.69 MPa). The measured pressure drops were compared first with each other, and then with correlations from literature. It was found that the best agreement between predicted and measured values is obtained by the method of Thom for a smooth tube and by Müller-Steinhagen and Heck’s method for a porous coated tube respectively.

08/02272 Effective thermal conductivity of moistened insulation materials as a function of temperature

Ochs, F. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 539–552.

Seasonal heat stores for waste heat applications or solar assisted district heating systems require thermal insulation in order to minimize heat losses. The insulation of these thermal energy stores is exposed to environmental influences. Especially the insulation of buried tank or pit heat stores may degrade due to increased moisture content caused by penetrating water (vapour). The effective thermal resistance of insulation materials decreases with increasing temperature and moisture content. Hence, thermal losses may become higher than the design values. For the insulation of buried heat stores bulk materials are more suitable than sheets. However, the availability of measured data of the thermal conductivity of bulk insulation at higher temperatures and at elevated moisture contents is poor. Models for the thermal conductivity given in the VDI Heat Atlas and elsewhere have to be modified in order to obtain good agreement between calculated and measured data of the thermal conductivity of porous materials with partially closed and thus for water inaccessible pores. This paper gives a detailed description of modelling and measurement of the effective thermal conductivity of porous bulk materials at temperatures up to 80 °C and moisture contents below free water saturation.

08/02273 Entropy generation for natural convection by heated partitions in a cavity

Famouri, M. and Hooman, K. *International Communications in Heat and Mass Transfer*, 2008, 35, (4), 492–502.

Entropy generation for natural convection in a partitioned cavity, with adiabatic horizontal and isothermally cooled vertical walls, is studied numerically by both a FORTRAN code and the commercially available CFD-ACE software. Effects of the Rayleigh number, the position of the heated partition, and the dimensionless temperature difference on the local and average entropy generation rate are investigated. Proper scale analysis of the problem showed that, while fluid friction term has nearly no contribution to entropy production, the heat transfer irreversibility increases monotonically with the Nusselt number and the dimensionless temperature difference.

08/02274 Estimation of monthly average daily global solar irradiation using artificial neural networks

Mubiru, J. and Banda, E. J. K. B. *Solar Energy*, 2008, 82, (2), 181–187.
This study explores the possibility of developing a prediction model using artificial neural networks (ANN), which could be used to estimate monthly average daily global solar irradiation on a horizontal surface for locations in Uganda based on weather station data: sunshine duration, maximum temperature, cloud cover and location parameters: latitude, longitude, altitude. Results have shown good agreement between the estimated and measured values of global solar irradiation. A correlation coefficient of 0.974 was obtained with mean bias error of 0.059 MJ/m^2 and root mean square error of 0.385 MJ/m^2. The comparison between the ANN and empirical method emphasized the superiority of the proposed ANN prediction model.

08/02275 Estimation of non-linear continuous time models for the heat exchange dynamics of building integrated photovoltaic modules

Jiménez, M. J. *et al. Energy and Buildings*, 2008, 40, (2), 157–167.
This paper advocates the use of continuous–discrete stochastic state space models in the form of non-linear partially observed stochastic differential equations (SDE's) – with measurement noise for modelling dynamic systems in continuous time using discrete time data. First of all the proposed method provides a method for modelling non-linear systems with partially observed states. The approach allows parameters to be estimated from experimental data in a prediction error (PE) setting, which gives less biased and more reproducible results in the presence of significant process noise than the more commonly used output error (OE) setting. To facilitate the use of continuous–discrete stochastic state space models, a PE estimation scheme that features maximum likelihood (ML) and maximum a posteriori (MAP) estimation is presented along with a software implementation. As a case study, the modelling of the thermal characteristics of a building-integrated PV component is considered. The EC-JRC Ispra has made experimental data available. Both linear and non-linear models are identified. It is shown that a description of the non-linear heat transfer is essential. The resulting model is a non-linear first order stochastic differential equation for the heat transfer of the PV component.

08/02276 Estimation of the advanced TCP/IP algorithms for long distance collaboration

Yamamoto, T. *Fusion Engineering and Design*, 2008, 83, (2–3), 516–519.
ITER collaboration needs the wide bandwidth network for the fast data transfer. However, the throughput might be too small to transfer the bulk data, because the delay of the signal is not negligible. This problem comes from the mechanism of the communication protocol, TCP/IP. In this paper, long fat pipe network (LFN) environment was emulated by the Linux-based PC. The effects of the various congestion avoidance algorithms were investigated with the delay which was estimated between ITER site in France and ITER satellite site in Japan. The standard algorithm, Reno, is not suitable for LFN. The advanced algorithm, CUBIC-TCP, Hamilton TCP and Scalable TCP can be more suitable for LFN such as the ITER international collaboration.

08/02277 Exergoeconomic analysis of a combined heat and power (CHP) system

Balli, O. *et al. International Journal of Energy Research*, 2008, 32, (4), 273–289.
This study deals with exergoeconomic analysis of a combined heat and power (CHP) system along its main components installed in Eskisehir City of Turkey. Quantitative exergy cost balance for each component and the whole CHP system is considered, while exergy cost generation within the system is determined. The exergetic efficiency of the CHP system is obtained to be 38.33% with 51 475.90 kW electrical power and the maximum exergy consumption between the components of the CHP system is found to be 51 878.82 kW in the combustion chamber. On the other hand, the exergoeconomic analysis results indicate that the unit exergy cost of electrical power produced by the CHP system accounts for 18.51 US\$ GW^{-1}. This study demonstrates that exergoeconomic analysis can provide extra information than exergy analysis, and the results from exergoeconomic analysis provide cost-based information, suggesting potential locations for the CHP system improvement.

08/02278 Filtering algorithm for radial displacement measurements of a dented pipe

Hojjati, M. H. and Lukasiewicz, S. A. *International Journal of Pressure Vessels and Piping*, 2008, 85, (5), 344–349.
Experimental measurements are always affected by some noise and errors caused by inherent inaccuracies and deficiencies of the experimental techniques and measuring devices used. In some fields, such as strain calculations in a dented pipe, the results are very sensitive to the errors. This paper presents a filtering algorithm to remove noise and errors from experimental measurements of radial displacements of a dented pipe. The proposed filter eliminates the errors without harming the measured data. The filtered data can then be used to estimate membrane and bending strains. The method is very effective and easy to use and provides a helpful practical measure for inspection purposes.

08/02279 Forecasting of solid waste composition using fuzzy regression approach: a case of Delhi

Srivastava, A. K. and Nema, A. K. *International Journal of Environment and Waste Management*, 2008, 2, (1–2), 65–74.
Fuzzy regression based approach has been used for forecasting the solid waste composition of Delhi, India between years 2007 to 2024. The estimates show that the plastic content of the waste is expected to increase from 2.74% to 3.55%. The percentages of paper and food waste are expected to decrease from 29.50% to 24.58% and from 36.37% to 27.55% respectively. The metals and glass has been estimated to increase to triple and double respectively. The findings emphasize the importance of forecasting waste composition and the significance of waste segregation for efficient operation of various reuse-recycle, treatment and disposal facilities.

08/02280 Free and forced convection heat transfer in the thermal entry region for laminar flow inside a circular cylinder horizontally oriented

Mohammed, H. A. *et al. Energy Conversion and Management*, 2007, 48, (7), 2185–2195.
An experimental work is conducted on combined (free and forced) convection to study the local and average heat transfer for hydrodynamically fully developed and thermally developing laminar air flow in a horizontal circular cylinder. The experimental setup uses an aluminium cylinder as test section with 30 mm inside diameter and 900 mm heated length ($L/D = 30$) subjected to a constant wall heat flux boundary condition. The investigation covers the Reynolds number range from 400 to 1600 and the heat flux range from 60 W/m^2 to 400 W/m^2. The fully developed condition is achieved by using aluminium entrance section pipes (calming sections) having the same inside diameter as the test section pipe but with variable lengths. The entrance sections included two long calming sections, one with length of 180 cm ($L/D = 60$), and the other with length of 240 cm ($L/D = 80$), and two short calming sections with lengths of 60 cm ($L/D = 20$) and of 120 cm ($L/D = 40$). The surface temperature distribution along the cylinder surface and the local and average Nusselt number distributions with dimensionless axial distance Z^+ were presented. For all entrance sections, an increase in the Nusselt number values was found as the heat flux increases. It was concluded that the free convection effects tended to decrease the heat transfer results at low *Re* number and to increase the heat transfer results for high *Re* number. The combined convection regime could be bounded by a suitable selection of *Re* number ranges and heat flux ranges. The obtained Richardson numbers (*Ri*) ranged approximately from 0.1171 to 7.125. The average Nusselt numbers were correlated with the Rayleigh numbers/Reynolds numbers.

08/02281 Functionally graded hollow spheres under non-axisymmetric thermo-mechanical loads

Poultangari, R. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (5), 295–305.
An analytical method is developed to obtain the solution for the two-dimensional (r,θ) steady state thermal and mechanical stresses in a hollow thick sphere made of functionally graded material. The material properties are assumed to vary through the thickness according to the power law functions. The temperature profile is obtained solving the functionally graded energy equation. The Navier equations are solved analytically using the Legendre polynomials and the system of Euler differential equations. Temperature, displacement components and stresses distributions are obtained and plotted for different power law indices. The results are validated with the known data in literature.

08/02282 Fuzzy control system for thermal and visual comfort in building

Kristl, Z. *et al. Renewable Energy*, 2008, 33, (4), 694–702.
In the era of informational and technological breakthrough, the automatically controlled living and working environment is expected to become a commonly used service. This paper deals with dynamically controlled thermal and illumination responses of built environment in real-time conditions. The aim is to harmonize thermal and optical behaviour of a building by coordinating energy flows that pass through the transparent part of the envelope. For this purpose, a test chamber with an opening on the southern side was built. Changeable geometry

of the opening is achieved by the automated external roller blind. A fuzzy control system enables the positioning of the shading device according to the desired indoor set points and the outdoor conditions. Through the experiments, the fuzzy controllers were tuned and gradually improved. Some sets of the experiments are presented here to illustrate the process.

08/02283 Heat transfer enhancement of fatty acids when used as PCMs in thermal energy storage

Mazman, M. *et al. International Journal of Energy Research*, 2008, 32, (2), 135–143.

Phase change materials (PCM) used in latent heat storage systems usually have very low thermal conductivities. This is a major drawback in maintaining the required heat exchange rate between PCM and heat transfer fluid. This paper investigates the enhancement of the heat transfer between PCM and heat transfer fluid, using high thermal conductivity as additives like stainless steel pieces, copper pieces and graphite-PCM composite material. In the experiments, palmitic-lauric acid (80:20) (PL) and stearic-myristic acid (80:20) (SM) were used as PCMs. Test results show that heat transfer enhancement of copper pieces was better at $0.05\,\mathrm{L\,s^{-1}}$ flow rate compared to $0.025\,\mathrm{L\,s^{-1}}$. Using copper as an additive increased the heat transfer rate 1.7 times for melting and 3.8 times for freezing when flow rate was $0.50\,\mathrm{L\,s^{-1}}$. Decreasing the flow rate from 0.050 to $0.025\,\mathrm{L\,s^{-1}}$, increased the melting times 1.3 times and freezing times 1.8 times, decreasing heat transfer rates accordingly. The best result of heat transfer enhancement was observed for the PCM-graphite composite. However, changing the flow rate did not affect the heat transfer rate when graphite was used as additive.

08/02284 *In situ* observation of lithium hydride hydrolysis by DRIFT spectroscopy

Awbery, R. P. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 94–102.

Polycrystalline LiH was studied *in situ* using diffuse reflectance infrared Fourier transform (DRIFT) spectroscopy to investigate the effect water vapour has on the rate of production of the corrosion products, particularly LiOH. The reaction rate of the formation of surface LiOH was monitored by measurement of the hydroxyl (OH) band at $3676\,\mathrm{cm^{-1}}$. The initial hydrolysis rate of LiH exposed to water vapour at 50% relative humidity was found to be almost two times faster than LiH exposed to water vapour at 2% relative humidity. The hydrolysis rate was shown to be initially very rapid followed by a much slower, almost linear rate. The change in hydrolysis rate was attributed to the formation of a coherent layer of LiOH on the LiH surface. Exposure to lower levels of water vapour appeared to result in the formation of a more coherent corrosion product, resulting in effective passivation of the surface to further attack from water.

08/02285 Investigation of various polymeric materials for set-point temperature calibration in pyrolysis–gas chromatography–mass spectrometry (Py – GC–MS)

Lund, L. M. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 129–133.

The precision and long-term stability of pyrolysis probe set-point temperature calibration of a commercially available coiled-filament pyrolyser were assessed for a variety of polymers, including Kraton® D1107, high-density polyethylene (HDPE), and low-density polyethylene (LDPE). While plots of peak area ratios for Kraton and HDPE versus pyrolysis set-point temperatures produced statistically significant linear curves at the 95% confidence level, poor precision was observed at each of the set-point temperatures. Plots of peak area ratios for LDPE, in particular for *n*-C16 alkyldiene/n-C$_{16}$ alkene peak area ratios, also exhibited good linearity but showed significant improvements in precision at each set-point temperature. In addition, replicate analysis over a 10-month period of peak area ratios for polymers pyrolysed at a set-point temperature of 900 °C confirmed the improved method precision obtained from pyrolysis of LDPE and analysis of the n-C$_{16}$ alkyldiene/n-C$_{16}$ alkene ratio when compared to the precision obtained from pyrolysis of Kraton D1107 or high-density polyethylene.

08/02286 Mathematic models of photovoltaic motor-pump systems

Hamidat, A. and Benyoucef, B. *Renewable Energy*, 2008, 33, (5), 943–949.

Photovoltaic (PV) pumping offers the possibility of supplying water to remote and desert regions for their daily needs. The sizing of the PV pumping systems is a very significant step in order to optimize the power peak of the PV array and to ensure the best choice of the motor, the pump and the inverter. Two mathematical models were proposed in this article to contribute in the studies of PV pumping sizing. These models link directly the operating electrical power to the water flow rate of the pump versus total head. These models are based essentially on the experimentation of pumps on CDER PV pumping test facility. Two pumping systems are tested: the first uses a centrifugal pump and the second uses a positive displacement pump. The results obtained by the models are very satisfactory. Also, the models enabled us to simulate the electrical and hydraulic performances of two tested pumps. The performances are calculated using the measured meteorological data of different sites located in Sahara and coastline regions of Algeria.

08/02287 Mechanism study of wood lignin pyrolysis by using TG–FTIR analysis

Liu, Q. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 170–177.

In order to study the pyrolysis mechanism of lignin, Van Soest's method was performed to extract lignin from different species of biomass. Fir and birch lignins were selected as the testing samples and corresponding microstructure was studied by a Fourier transform infrared spectrometry. Several characteristic bands were observed to show the presence and species of lignin. Following experimental research on pyrolysis of lignins from fir and birch were carried out on a thermogravimetric analyser coupled with a Fourier transform infrared spectrometry. Wood lignin undergoes in three consecutive stages, corresponding to the evaporation of water, the formation of primary volatiles and the subsequent release of small molecular gases. The main pyrolysis sections and the maximum weight loss rates are quite different for different wood species. Phenols are the main volatile products, in addition to alcohols, aldehydes, acids, and so on. As the main gaseous products, CO, CO_2, CH_4 are released out greatly.

08/02288 Modeling of a hazelnut dryer assisted heat pump by using artificial neural networks

Ceylan, I. and Aktaş, M. *Applied Energy*, 2008, 85, (9), 841–854.

The artificial neural network (ANN) approach is generic technique for mapping non-linear relationships between inputs and outputs without knowing the details of these relationships. In this paper, an application of the ANN has been presented for a PID (proportional integral derivative) controlled heat pump dryer. In a PID controlled heat pump dryer, air velocity changed according to the temperature value set in the process control device. Heat pump dryer was tested by drying hazelnuts at 40 °C, 45 °C and 50 °C drying air temperatures. By training the experiment results with ANN, drying air velocities, moisture content of hazelnuts and total drying time were predicted for 42 °C, 44 °C, 46 °C and 48 °C drying air temperatures.

08/02289 Modeling of the optimum tilt of a solar chimney for maximum air flow

Sakonidou, E. P. *et al. Solar Energy*, 2008, 82, (1), 80–94.

The aim of this work is to develop a mathematical model to determine the tilt that maximizes natural air flow inside a solar chimney using daily solar irradiance data on a horizontal plane at a site. The model starts by calculating the hourly solar irradiation components (direct, diffuse, ground-reflected) absorbed by the solar chimney of varying tilt and height for a given time (day of the year, hour) and place (latitude). In doing so it computes the transmittance and absorbance of the glazing for the various solar irradiation components and for various tilts. The model predicts the temperature and velocity of the air inside the chimney as well as the temperatures of the glazing and the black painted absorber. Comparisons of the model predictions with CFD calculations delineate the usefulness of the model. In addition, there is a good agreement between theoretical predictions and experiments performed with a 1 m long solar chimney at different tilt positions.

08/02290 Modelling and Pareto optimization of heat transfer and flow coefficients in microchannels using GMDH type neural networks and genetic algorithms

Amanifard, N. *et al. Energy Conversion and Management*, 2008, 49, (2), 311–325.

Three-dimensional heat transfer characteristics and pressure drop of water flow in a set of rectangular microchannels are numerically investigated using Fluent and compared with those of experimental results. Two metamodels based on the evolved group method of data handling (GMDH) type neural networks are then obtained for modelling of both pressure drop (ΔP) and Nusselt number (Nu) with respect to design variables such as geometrical parameters of microchannels, the amount of heat flux and the Reynolds number. Using such obtained polynomial neural networks, multi-objective genetic algorithms (non-dominated sorting genetic algorithm, NSGA-II) with a new diversity preserving mechanism is then used for Pareto based optimization of microchannels considering two conflicting objectives such as (ΔP) and (Nu). It is shown that some interesting and important relationships as useful optimal design principles involved in the performance of microchannels can be discovered by Pareto based multi-objective optimization of the obtained polynomial metamodels representing their heat transfer and flow characteristics.

Such important optimal principles would not have been obtained without the use of both GMDH type neural network modelling and the Pareto optimization approach.

08/02291 Multi-criteria fuzzy algorithm for energy management of a domestic photovoltaic panel

Salah, C. B. *et al. Renewable Energy*, 2008, 33, (5), 993–1001.

This paper presents a fuzzy algorithm that makes decision so as to connect domestic apparatus on either the electrical grid or a photovoltaic panel (PVP). The decision is made in real time with respect to multi-energy save criteria and upon the PVP maximum available power and apparatus states. The algorithm is validated on a 1 kW peak (kWp) PVP and domicile apparatus of different powers installed at the Energy and Thermal Research Centre in the north of Tunisia. Criteria are verified on the system behaviour during days covering the different seasons of the year. The power audit, established using measures, confirms that the energy save during daylight reaches 90% of the PVP available energy.

08/02292 Numerical simulation of coupled heat transfers by conduction, natural convection and radiation in hollow structures heated from below or above

Ait-taleb, T. *et al. International Journal of Thermal Sciences*, 2008, 47, (4), 378–387.

Coupled heat transfers in hollow structures uniformly heated from below or from above are numerically investigated. Discussions of the results are for structures formed by a range of three identical rectangular cavities with end vertical side walls of the structure assumed adiabatic or submitted to periodic conditions. The Boussinesq approximation is invoked and the flows are considered laminar and two-dimensional for the whole range of parameters considered. Conduction heat transfer in the solid partitions and surface radiation amongst grey diffuse surfaces are accounted for. The conservation equations are solved by a finite difference method and the pressure–velocity coupling solved by the SIMPLE algorithm.

08/02293 Numerical simulation of the solar chimney power plant systems coupled with turbine

Ming, T. *et al. Renewable Energy*, 2008, 33, (5), 897–905.

Numerical simulations have been carried out on the solar chimney power plant systems coupled with turbine. The whole system has been divided into three regions: the collector, the chimney and the turbine, and the mathematical models of heat transfer and flow have been set up for these regions. Using the Spanish prototype as a practical example, numerical simulation results for the prototype with a three-blade turbine show that the maximum power output of the system is a little higher than 50 kW. Furthermore, the effect of the turbine rotational speed on the chimney outlet parameters has been analysed which shows the validity of the numerical method advanced by the author. Thereafter, design and simulation of a MW-graded solar chimney power plant system with a five-blade turbine have been presented, and the numerical simulation results show that the power output and turbine efficiency are 10 MW and 50%, respectively, which presents a reference to the design of large-scale solar chimney power plant systems.

08/02294 On the complexity of radiation models for PV energy production calculation

Perpiñan, O. *et al. Solar Energy*, 2008, 82, (2), 125–131.

Several authors have analysed the changes of the probability density function of the solar radiation with different time resolutions. Some others have approached to study the significance of these changes when produced energy calculations are attempted. The authors have undertaken different transformations to four Spanish databases in order to clarify the interrelationship between radiation models and produced energy estimations. The complexity of a solar radiation model needed for yearly energy calculations, is very low. Twelve values of monthly mean of solar radiation are enough to estimate energy with errors below 3%. Time resolutions better than hourly samples do not improve significantly the result of energy estimations.

08/02295 Precipitation of the FeCu system: a critical review of atomic kinetic Monte Carlo simulations

Vincent, E. *et al. Journal of Nuclear Materials*, 2008, 373, (1–3), 387–401.

Cu is of primary importance in the embrittlement of the neutron-irradiated reactor pressure vessel (RPV) steels. It has been observed to segregate into copper-rich precipitates within the ferrite matrix under irradiation. Since its role was discovered more than 40 years ago, Cu precipitation in *-Fe has been studied extensively under irradiation as well as under thermal ageing using atom probe tomography, small angle neutron scattering, and high resolution transmission electron microscopy. Numerical simulation techniques such as rate theory or Monte Carlo methods have also been used to investigate this problem, however not always with a great success. In this paper, a critical review of the different kinetic Monte Carlo models is provided dedicated to the study of Cu precipitation, with the aim of determining which elements are key to an accurate description of precipitation.

08/02296 Radial basis function neural network for power system load-flow

Karami, A. and Mohammadi, M. S. *International Journal of Electrical Power & Energy Systems*, 2008, 30, (1), 60–66.

This paper presents a method for solving the load-flow problem of the electric power systems using radial basis function (RBF) neural network with a fast hybrid training method. The main idea is that some operating conditions (values) are needed to solve the set of non-linear algebraic equations of load-flow by employing an iterative numerical technique. Therefore, the outputs of a load-flow program can be viewed as functions of the operating conditions. This leaves a function approximation problem, which can be addressed by an RBF neural network. The proposed approach has been successfully applied to the 10-machine and 39-bus New England test system. In addition, this method has been compared with that of a multi-layer perceptron (MLP) neural network model. The simulation results show that the RBF neural network is a simpler method to implement and requires less training time to converge than the MLP neural network.

08/02297 Selective harmonic elimination of new family of multilevel inverters using genetic algorithms

El-Naggar, K. and Abdelhamid, T. H. *Energy Conversion and Management*, 2008, 49, (1), 89–95.

Selective harmonic elimination has been a widely researched alternative to traditional PWM techniques. This paper presents the selective harmonic elimination of a new family of multilevel inverters using genetic algorithms. The new topology has the advantage of a reduced number of devices compared to traditional configurations and can be extended to any number of levels. The presented system reduces both the implementation complexity and the computational time. The GA technique finds the optimal solution set of switching angles, if it exists, for each required harmonic profile. Both simulation results and experimental verification of the proposed inverter topology for different numbers of levels and different harmonic profiles are presented.

08/02298 Simplified model and lattice Boltzmann algorithm for microscale electro-osmotic flows and heat transfer

Shi, Y. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 586–596.

The extremely small length scale of the electric double layer (EDL) of electro-osmotic flows in a microchannel makes it difficult to simulate such flows and associated thermal behaviours. A feasible solution to this problem is to neglect the details in the thin EDL and replace its effects on the bulk flow and heat transfer with effective velocity-slip and temperature-jump boundary conditions outside the EDL. In this paper, by carrying out a scale analysis on the fluid flow and heat transfer in the thin EDL, the velocity and the temperature were analytically obtained at the interface between the EDL and the bulk flow region. The Navier–Stokes equations and the conservation equation of energy, along with the interfacial velocity and temperature as the velocity-slip and temperature-jump boundary conditions, form a simple model for the electro-osmotic flows with thermal effects in a microchannel with a thin EDL. The double distribution function lattice Boltzmann algorithm was used to solve this model and found that numerical results are in good agreement with those by the conventional complete model with inclusion of the EDL, particularly for the cases when channel size is about 400 times larger than the Debye length. Moreover, it was found that the present model can substantially reduce the computational time by four to five times of that using the conventional complete model. Therefore, the simplified model proposed in this work is an efficient tool for simulating electro-osmosis-based microfluidic systems.

08/02299 Solution of one-speed neutron transport equation for strongly anisotropic scattering by T_N approximation: slab criticality problem

Yilmazer, A. *Annals of Nuclear Energy*, 2007, 34, (9), 743–751.

In this study, a recently proposed version of Chebyshev polynomial approximation which was used in spectrum and criticality calculations by one-speed neutron transport equation for slabs with isotropic scattering is further developed to slab criticality problems for strongly anisotropic scattering. Backward–forward-isotropic model is employed for the scattering kernel which is a combination of linearly anisotropic and strongly backward–forward kernels. Further to that, the common approaches of using the same functional form for scattering and fission kernels or embedding fission kernel into the scattering kernel even in strongly anisotropic scattering is questioned for T_N approximation via taking an isotropic fission kernel in the transport equation. As a starting point, eigenvalue spectrum of one-speed neutron transport equation for a multiplying slab with different degrees of anisotropy in scattering and for different cross-section parameters is obtained using Chebyshev method. Later on, the spectra obtained for different degree of anisotropies and cross-section parameters are made use of in criticality problem of bare homogeneous slab with strongly anisotropic scattering. Calculated critical thicknesses by Chebysev method are almost in complete agreement with literature data except for some limiting cases. More importantly, it is observed that using a different kernel (isotropic) for fission rather than assuming it equal to the scattering kernel which is a more realistic physical approach yields in deviations in critical sizes in comparison with the values presented in literature. This separate kernel approach also eliminates the slow convergency and/or non-convergent behaviour of high-order approximations arising from unphysical eigenspectrum calculations.

08/02300 Studies on thermal characteristics of ice thermal storage tank and a methodology for estimation of tank efficiency

Yamaha, M. *et al. International Journal of Energy Research*, 2008, 32, (3), 226–241.

Thermal energy storages that store energy as heat, can compensate energy imbalance between heat generation and consumption. Several types of ice storage systems are applied to heating, ventilating, and air conditioning systems. In this paper, experiments on ice-on-coil and dynamic type are reported to examine thermal characteristics of tanks according to dimensionless response of outlet temperature. Efficiencies of the tank are discussed with respect to dimensionless response, response in a system and volumetric consideration of the tank. For the ice-on-coil type, the Archimedes number at inlet and the inlet enthalpy flow rate are the dominant parameters. Large Archimedes number and intermediate enthalpy flow rate result in lower outlet temperatures. For the dynamic type, as the mechanism of heat transfer is slightly different from the ice-on-coil type, higher velocity of inlet water maintains a lower outlet temperature. From the experimental results, simulation models for both types were developed. Simulations were conducted to estimate the volumetric efficiency under various conditions, considering actual applications. Eight factors were selected as design conditions. The relations among these factors and their potential effects on the thermal characteristics and the volumetric efficiency were derived by system simulations. The significance of the factors on the system was quantified and different effects on ice-on-coil and dynamic ice storage systems were found. Estimation tables to determine volumetric efficiency from the significant factors are presented.

08/02301 TG-FTIR analysis of PVC thermal degradation and HCl removal

Zhu, H. M. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 82, (1), 1–9.

The pyrolysis of polyvinyl chloride (PVC) was qualitatively analysed by TG-FTIR, and HCl removal efficiency of Ca-based additives were semi-quantitatively studied also by means of TG-FTIR. Additionally, the thermodynamic equilibrium modelling was also carried out to understand the formation of HCl from PVC and from mixtures of PVC with different additives. Experimental results showed that the pyrolysis of PVC took place in two steps accompanied by the release of HCl and hydrocarbon, respectively. Almost all Cl transformed to HCl, and hardly any other kinds of Cl compounds were detected. The addition of Ca-based additives extended the second weight loss step of PVC, but they did not affect the release time when the maximum HCl concentration appeared. The maximum HCl concentration decreased according to the increase of additive amount, that is to say, the HCl removal efficiency increased as the Ca/Cl molar ratio increased, however when the Ca/Cl ratio increased to a certain value, the increase of HCl removal efficiency was not proportional to the increase of additive amount. For different additives, different Ca/Cl ratios should be chosen based on the cost, HCl removal efficiency and utilization efficiency of additive.

08/02302 The first and second law analysis of a lithium bromide/water coil absorber

Kaynakli, O. *Energy*, 2008, 33, (5), 804–816.

The aim of this paper is to study the irreversibilities in a coil absorber using lithium bromide solution and to determine the variation of the second law efficiency with some variables such as cooling water flow rate, solution flow rate, cooling water temperature and solution concentration. The influence of absorber performance parameters is examined on the basis of the first and second laws of thermodynamics for parallel and counter-current types. In this regard, the heat and mass transfer, the second law efficiency, the magnitude and place of exergy losses in two types of absorbers are estimated and discussed comprehensively. The results showed that increasing the cooling water flow rate and decreasing the cooling water inlet temperature increase the heat and mass transfer, and decrease the second law efficiency. The effect of the solution concentration on the efficiency in general is small. Whereas the irreversibility for the counter-current mode is greater than that of the parallel-current mode, the heat-mass transfer 3–19% and the second law efficiency 1–12% are higher.

08/02303 The prediction of convective heat transfer in floor-heating systems by artificial neural networks

Karadag, R. and Akgöbek, Ö. *International Communications in Heat and Mass Transfer*, 2008, 35, (3), 312–325.

In this study the floor Nusselt and Rayleigh numbers for the floor-heating systems are estimated by the artificial neural networks (ANN). Numerical data for the floor Nusselt and Rayleigh numbers are available in the literature. A piece of the numerical values are used for training the ANN. The values estimated by the ANN are compared with the numerical values and the results of an equation given in the literature. It has been seen that the results of the ANN are very close to the numerical data and the results of the equation.

08/02304 Thermal characterization of mustard straw and stalk in nitrogen at different heating rates

Maiti, S. *et al. Fuel*, 2007, 86, (10–11), 1513–1518.

The pyrolysis of mustard straw and stalk was investigated at different heating rates from the ambient temperature to a temperature of 700 °C in a dynamic nitrogen flow of 40 cc/min. The thermogravimetric and derivative thermogravimetric analysis profiles were examined for the entire degradation zone to determine the order of reaction, pre-exponential factor and activation energy. The orders of reaction were in the range of 0.61–1.02, activation energy in the range of 10.83–21.63 kJ/mol and pre-exponential factor was in the range of 15.67–27.2 min^{-1}. This study of kinetics of pyrolysis of this abundant biomass is helpful in developing the mechanism of a thermochemical conversion process.

08/02305 Three dimensional modeling on airflow, heat and mass transfer in partially impermeable enclosure containing agricultural produce during natural convective cooling

Chourasia, M. K. and Goswami, T. K. *Energy Conversion and Management*, 2007, 48, (7), 2236–2149.

A three-dimensional model was developed to simulate the transport phenomena in heat and mass generating porous medium cooled under natural convective environment. Unlike the previous works on this aspect, the present model was aimed for bulk stored agricultural produce contained in a permeable package placed on a hard surface. This situation made the bottom of the package impermeable to fluid flow as well as moisture transfer and adiabatic to heat transfer. The velocity vectors, isotherms and contours of rate of moisture loss were presented during transient cooling as well as at steady state using the commercially available computational fluid dynamics (CFD) code based on the finite volume technique. The CFD model was validated using the experimental data on the time–temperature history as well as weight loss obtained from a bag of potatoes kept in a cold store. The simulated and experimental values on temperature and moisture loss of the product were found to be in good agreement.

08/02306 Three-dimensional numerical analysis of PEM fuel cells with straight and wave-like gas flow fields channels

Kuo, J.-K. *et al. Journal of Power Sources*, 2008, 177, (1), 96–103.

Using a three-dimensional computational model, numerical simulations are performed to investigate the performance characteristics of proton exchange membrane fuel cells (PEMFCs) incorporating either a conventional straight gas flow channel or a novel wave-like channel. The simulations focus particularly on the effect of the wave-like surface on the gas flow characteristics, the temperature distribution, the electrochemical reaction efficiency and the electrical performance of the PEMFCs at operating temperatures ranging from 323 to 343 K. The numerical results reveal that the wave-like surface enhances the transport of the reactant gases through the porous layer, improves the convective heat transfer effect, increases the gas flow velocity, and yields a more uniform temperature distribution. As a result, the efficiency of the catalytic reaction is significantly improved. Consequently, compared to a conventional PEMFC, the PEMFC with a wave-like channel yields a notably higher output voltage and power density.

08/02307 Virtual reality applied to a full simulator of electrical sub-stations

Romero, G. *et al. Electric Power Systems Research*, 2008, 78, (3), 409–417.

This paper presents an application designed to train electrical sub-station operators by means of a virtual reality environment. The application allows full viewing of any of the sub-stations in the power supply network. With the appropriate hardware (HMD, 3D mouse and tracking systems) it is possible to navigate into the virtual world and interact with the elements. Each of the sub-station components has been reproduced in the simulation model, including the behaviour laws associated with it, so the complete functionality of the sub-station can be simulated. This module is built into a larger and more complex computer system composed of the actual sub-station control system, the Geographical Information System which defines the topology of the network, and the functional system which simulates the electrical behaviour of the sub-station. The application automatically updates in the virtual environment any changes to the sub-station's design and allows access, from this environment, to information on every component. The virtual reality application has been implemented in a hardware configuration and has the same interface as that used in the control system of the real sub-station. In this way, the system developed can be integrated into a replica of the complete power supply network control system emulating a real sub-station, it being able to fully interact with the global system, and allow totally real situations to be simulated.

Fuel cell technology

08/02308 A high-performance no-chamber fuel cell operated on ethanol flame

Wang, K. *et al. Journal of Power Sources*, 2008, 177, (1), 33–39.

A no-chamber solid-oxide fuel cell operated on a fuel-rich ethanol flame was reported. Heat produced from the combustion of ethanol thermally sustained the fuel cell at a temperature of 500–830 °C. Considerable amounts of hydrogen and carbon monoxide were also produced during the fuel-rich combustion, which provided the direct fuels for the fuel cell. The location of the fuel cell with respect to the flame was found to have a significant effect on the fuel cell temperature and performance. The highest power density was achieved when the anode was exposed to the inner flame. By modifying the $Ni + Sm_{0.2}Ce_{0.8}O_{1.9}$ (SDC) anode with a thin Ru/SDC catalytic layer, the fuel cell envisaged not only an increase of the peak power density to $200\,mW\,cm^{-2}$ but also a significant improvement of the anodic coking resistance.

08/02309 A review on macro-level modeling of planar solid oxide fuel cells

Coplan, C. O. *et al. International Journal of Energy Research*, 2008, 32, (4), 336–355.

In this review paper, a comprehensive literature survey on macro-level modelling of solid oxide fuel cells (SOFCs) is presented. First, the current status of the SOFC modelling is assessed. Second, modelling techniques are discussed in detail. These include the thermodynamics, electrochemistry and heat transfer aspects of the modelling. Thermodynamic relations for pure hydrogen as the fuel and then gas mixture as the fuel are given. Additionally, exergy destructed due to polarizations is shown. Then, modelling equations for ohmic, activation, and concentration polarizations are given. Handling the carbon deposition problem in the modelling is discussed. The inclusion of the convection and radiation heat transfer processes to the modelling is explained. Finally, the models in literature are compared in terms of the methodology used and suggestions for increasing the accuracy of the future models are given.

08/02310 A suitable model plant for control of the set fuel cell-DC/DC converter

Andújar, J. M. *et al. Renewable Energy*, 2008, 33, (4), 813–826.

In this work a state and transfer function model of the set made up of a proton exchange membrane fuel cell and a DC/DC converter is developed. The set is modelled as a plant controlled by the converter duty cycle. In addition to allow setting the plant operating point at any point of its characteristic curve (two interesting points are maximum efficiency and maximum power points), this approach also allows the connection of the fuel cell to other energy generation and storage devices, given that, as they all usually share a single DC bus, a thorough control of the interconnected devices is required. First, the state and transfer function models of the fuel cell and the converter are obtained. Then, both models are related in order to achieve the fuel cell+DC/DC converter set (plant) model. The results of the theoretical developments are validated by simulation on a real fuel cell model.

08/02311 Analysis of a passive vapor feed direct methanol fuel cell

Rice, J. and Faghri, A. *International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 948–959.

The passive fuel delivery systems presented thus far have utilized the liquid phase as a transport medium. However, since methanol is a highly volatile component, the vapour phase can be utilized to transport methanol to the fuel cell. A one-dimensional analysis of the transport of methanol from the fuel source to the fuel cell is developed here, with the goal of describing the key issues. Operation of the fuel cell is further characterized with a full numerical model that captures transience, and also addresses fuel, water, and thermal management issues. The results show that the condensation of water onto a methanol evaporation pad needs to be limited if the operation time of the fuel cell is to increase.

08/02312 Bioelectricity production from wastewater treatment in dual chambered microbial fuel cell (MFC) using selectively enriched mixed microflora: effect of catholyte

Mohan, S. V. *et al. Bioresource Technology*, 2008, 99, (3), 596–603.

The performance of aerated and ferricyanide catholytes on the bioelectricity production was evaluated in dual chambered microbial fuel cell (MFC) (mediatroless anode; graphite electrodes) employing selectively enriched H_2 producing mixed consortia as anodic inoculum. Two MFCs with aerated catholyte (MFC_{AC}) and ferricyanide catholyte (MFC_{FC}) were operated separately to elucidate the difference in power generation potential and carbon removal efficiency under similar operating conditions [ambient pressure; room temperature (28 ± 2 °C); acidophilic microenvironment (pH 6)]. The experimental data demonstrated the feasibility of in situ bioelectricity generation along with wastewater treatment. Effective power generation and substrate removal efficiency was documented in the fuel cell operated with ferricyanide catholyte (586 mV; 2.37 mA; 0.559 kg COD/m^3 day) than aerated catholyte (572 mV; 1.68 mA; 0.464 kg COD/m^3 day). Maximum power yield (0.635 W/kg COD_R and 0.440 W/kg COD_R) and current density (222.59 mA/m^2 and 190.28 mA/m^2) was observed at 100 Ω resistor with ferricyanide and aerated catholytes, respectively. The study documented both wastewater treatment and electricity production through direct conversion of H_2 in a single system.

08/02313 Catalytic hydrogen/oxygen reaction assisted the proton exchange membrane fuel cell (PEMFC) startup at subzero temperature

Sun, S. *et al. Journal of Power Sources*, 2008, 177, (1), 137–141.

Fuel cells for automobile application need to operate in a wide temperature range including freezing temperature. However, the rapid startup of a proton exchange membrane fuel cell (PEMFC) at subfreezing temperature, e.g. –20 °C, is very difficult. A cold-start procedure was developed, which made hydrogen and oxygen react to heat the fuel cell considering that the FC flow channel was the characteristic of microchannel reactor. The effect of hydrogen and oxygen reaction on fuel cell performance at ambient temperature was also investigated. The electrochemical characterizations such as *I–V* plot and cyclic voltammetry (CV) were performed. The heat generated rate for either the single cell or the stack was calculated. The results showed that the heat generated rate was proportional to the gas flow rate when H_2 concentration and the active area were constant. The fuel cell temperature rose rapidly and steadily by controlling gas flow rate.

08/02314 Comparison of different approaches for lifetime prediction of electrochemical systems – using lead-acid batteries as example

Sauer, D. U. and Wenzl, H. *Journal of Power Sources*, 2008, 176, (2), 534–546.

Different approaches for lifetime prediction for electrochemical energy storage devices are discussed with respect to their general concepts. Examples for their implementation and advantages and disadvantages are given. The models are based on: (a) physical and chemical processes and their interaction as regards ageing effects; (b) weighting of the Ah throughput whenever the operating conditions deviate from the standard conditions used for determining the lifetime under laboratory conditions; (c) an event-oriented concept from mechanical engineering (Wöhler curves) which is based on a pattern recognition approach to identify severe operating conditions. Examples and details are explained for lead-acid batteries. The approaches can be applied to other electrochemical technologies including fuel cells. However, it is beyond the scope of this paper, to describe the models in all mathematical details. The models are used in system design and identification of appropriate operating strategies and therefore they must have high computational speed to allow for a comparison of a large number of system variations.

08/02315 Development of a 1 W passive DMFC

Guo, C. and Faghri, A. *International Communications in Heat and Mass Transfer*, 2008, 35, (3), 225–239.

In this paper, development techniques for a passive DMFC prototype in the 1 W range are described in detail. The prototype includes a fuel cell stack, a fuel tank and a passive ancillary system (termed 'thermal-fluids management system' in this paper). The fuel cell stack in this study incorporates a window-frame structure that provides a large open area for more efficient mass transfer and is modular. Two stack units connected in series, with a total combined active area of $72.0\,cm^2$, are used in the prototype. The thermal-fluids management system utilizes passive approaches for fuel storage and delivery, air-breathing, water management, CO_2 release, and thermal management. The air filter also serves as a waterproof layer for the cathode in order to prevent water contamination. Water immersion tests are conducted to evaluate the air filter. The performance evaluation of the prototype is performed in two fuel feeding modes: dilute methanol solution and pure methanol. A peak power output of 1.5 W is achieved with the dilute methanol solution feed.

08/02316 Dynamic conducting effect of WO_3/PFSA membranes on the performance of proton exchange membrane fuel cells

Yang, J. *et al. Journal of Power Sources*, 2008, 177, (1), 56–60.

The homogenous proton conducting WO_3/PFSA membranes are prepared based on a dynamic conducting concept, that is, the resistance of the membrane can be reduced during the fuel cell operation due to the formation of the conducting hydrogen tungsten bronzes. The novel membranes are characterized by different techniques. The results proved that the resistances of the WO_3-containing membranes in single fuel cells measured by in situ AC impedance spectroscopy during the operation are significantly lower than that of the single fuel cell using Nafion® 112 membrane. It is revealed that the performances of the single fuel cells with WO_3/PFSA membranes are superior to that of the single cell with Nafion 112 membrane.

08/02317 Economic and technical analysis of a hybrid wind fuel cell energy system

Samaniego, J. *et al. Renewable Energy*, 2008, 33, (5), 839–845.

This paper presents the simulation and analysis of a system created by the combination of a wind turbine, an electrolyser and a fuel cell working together in order to provide constant electric energy supply over 1 year. The entire system is simulated according to two different operation strategies focused mainly on the operation of the electrolyser at either constant nominal operating power or varying from 20% to nominal operation. The different configurations and dimensions of every component of the system are tested. The entire system has been created using TRNSYS 15 software which permits global simulation and behaviour analysis. Using this tool, it is possible to specify the viability based on technical and economic aspects.

08/02318 Energy system analysis of the fuel cell buses operated in the project: clean urban transport for Europe

Saxe, M. *et al. Energy*, 2008, 33, (5), 689–711.

During the project Clean Urban Transport for Europe (CUTE), which ended in May 2006, 27 fuel cell buses were operated in nine European cities. In this paper key performance parameters from the operation of the fuel cell buses in the project are reported, the energy system of the bus is analysed and drive cycle tests in five cities are presented and analysed. The focus of the paper is on fuel consumption and optimization potential but experiences of, and recommendations for, evaluation in large demonstration projects are also presented. The results show that although the total fuel cell system efficiency was found to be high (36–41%), the fuel consumption was higher for the fuel cell buses than for diesel buses. Since the CUTE buses were a pre-commercial generation of fuel cell buses, with standard auxiliaries and extensive reliability measures, large fuel consumption reduction is possible. Suggestions on how to increase the efficiency is presented in this paper. Minimizing the reliability measures would decrease fuel consumption by about 20% and lowering the weight by 2 tonnes would decrease fuel consumption by another 10%. Hybridization in combination with using electrical auxiliaries could save an additional 5–10% or more.

08/02319 External determinants for the adoption of stationary fuel cells – infrastructure and policy issues

Karger, C. R. and Bongartz, R. *Energy Policy*, 2008, 36, (2), 798–810.

This paper investigates the relevance of external determinants for the adoption of stationary fuel cells (FCs) by different user groups with respect to the marketability of this innovative technology. FCs allow electricity and heat to be decentrally generated in an energy-efficient and potentially environmentally friendly manner. European energy policy is undertaking efforts to increase the proportion of combined heat and power (CHP) plants. A series of studies have spoken of their considerable market potential. A qualitative study was conducted with six focus groups consisting of 49 commercial users and six focus groups with 54 private consumers. The results of the study show that the specific infrastructure required for decentralization and policy issues are highly relevant for the user adoption of FCs. Security of supply when energy generation is more strongly decentralized, reliable maintenance of the system, and clear political objectives are examples of factors that are considered essential prerequisites for the adoption of this technology.

08/02320 Improved performance of Pd electrocatalyst supported on ultrahigh surface area hollow carbon spheres for direct alcohol fuel cells

Hu, F. P. *et al. Journal of Power Sources*, 2008, 177, (1), 61–66.

Ultrahigh surface area hollow carbon spheres (HCSs) with open micropores and nanochannels have been prepared by combined methods of hydrothermal and intermittent microwave heating (IMH) for the first time. It is found that the addition of poly(ethylene glycol)-block-poly(propylene glycol)-block-poly(ethylene glycol) (P123) leads to a large BET surface area of $1249.3\,m^2\,g^{-1}$. The catalytic activity of Pd supported on HCS is over three times higher than that on Pd supported on commercial Vulcan XC-72 carbon at the same Pd loadings. It is proven that the higher catalytic activity is contributed from the formation of the high electrochemical active surface area (EASA) which is due to the hollow carbon structure with open micropores and nanochannels.

08/02321 Natural gas electric generator powered by polymer exchange membrane fuel cell: numerical model and experimental results

Radulescu, M. *et al. Energy Conversion and Management*, 2008, 49, (2), 326–335.

The reduction of pollutant emissions is an important advantage of fuel cells in small stationary power systems, particularly in combined heat and power generation (CHP). In fact, fuel cells are one of the future practical solutions for micro-CHP systems (5–10 kW) in the domestic environment. This paper reports numerical and experimental results of 5 kWe CHP H-Power units running on natural gas. The natural gas is reformed locally to produce hydrogen. The numerical model of the units allows the simulation of the operation of the reformer, the cooler-shift, the prox (preferential oxidation reactor) and of the PEMFC. The PEMFC polarization curve is determined by a subroutine taking into account mass and charge transfers and the condensation of liquid water in the electrodes membrane assembly (EMA). The molar flux of species through the anode and cathode porous backing layers is calculated analytically by means of the Stefan–Maxwell equations. The gas channels are assumed parallel to the EMA, and the effects of concentration variation are investigated. The relevance of the numerical results is first validated by comparison with experimental data; then, the performances of the system are analysed in terms of electrical efficiency. Although the measured electrical performances are disappointing, the numerical simulations and analyses of experimental data suggest promising improvements. The model is employed to evaluate the best possible electrical efficiency and to establish the ideal operation domain of the installations.

08/02322 New electroplated aluminum bipolar plate for PEM fuel cell

Abo El-Enin, S. A. *et al. Journal of Power Sources*, 2008, 177, (1), 131–136.

Further improvement in the performance of the polymer electrolyte membrane fuel cells as a power source for automotive applications may be achieved by the use of a new material in the manufacture of the bipolar plate. Several nickel alloys were applied on the aluminum substrate, the use of aluminum as a bipolar plate instead of graphite is to reduce the bipolar plate cost and weight and the ease of machining. The electroplated nickel alloys on aluminum substrate produced a new metallic bipolar plate for PEM fuel cell with a higher efficiency and longer lifetime than the graphite bipolar plate due to its higher electrical conductivity and its lower corrosion rate. Different pretreatment methods were tested; the optimum method for pretreatment consists of dipping the specimen in a 12.5% NaOH for 3 min followed by electroless zinc plating for 2 min, then the specimen is dipped quickly in the electroplating bath after rinsing with distilled water. The produced electroplate was tested with different measurement techniques, chosen based on the requirement for a PEM fuel cell bipolar plate, including X-ray diffraction, EDAX, SEM, corrosion resistance, thickness measurement, microhardness, and electrical conductivity.

08/02323 Polyaniline and polypyrrole coatings on aluminum for PEM fuel cell bipolar plates

Joseph, S. *et al. Journal of Power Sources*, 2008, 177, (1), 161–166.

The conducting polymers polypyrrole and polyaniline were deposited on 6061 aluminum using cyclic voltammetry and painting, respectively. These samples are intended for proton exchange membrane fuel cell applications where surface contact resistance as well as bulk corrosion resistance are requirements for the bipolar plates that separate the cells. Corrosion current and voltage were measured on the samples as well as contact resistance between coated samples as a function of contact pressure. The polypyrrole samples showed neither improved corrosion resistance nor acceptable contact resistance. The painted polyaniline samples, however, showed about an order of magnitude reduction in corrosion current with only a minor increase in contact resistance. It is believed that in the more acidic environment of a fuel cell, the polyaniline will become even more conductive and that further reduction in contact resistance should be possible.

08/02324 Steam reforming of liquid hydrocarbon fuels for micro-fuel cells. Pre-reforming of model jet fuels over supported metal catalysts

Zheng, J. *et al. Fuel Processing Technology*, 2008, 89, (4), 440–448.

The present work deals with pre-reforming of logistic hydrocarbon fuel (jet fuel) as a part of an integrated approach to developing an on-board fuel reformer for use in a micro-solid-oxide fuel cell system. The purpose of doing pre-reforming is to ensure carbon-free reformulation of JP-8 jet fuel into hydrogen and carbon monoxide for use in a micro-solid-oxide fuel cell. Several model jet fuels have been tested for the pre-reforming at low temperature (450–550 °C) in a lab-scale reforming reactor. Proper temperature control and pre-mixing of feed fuels and steam have been found to be important for the prevention of coke formation prior to pre-reforming. Both noble metal and base-metal catalysts have been prepared and tested. As compared with an Al_2O_3-supported Ni catalyst, supported Rh catalysts show not only high activity but also high resistance to deactivation due to carbon formation. Removal of residual Cl^- from $Rh/CeO_2–Al_2O_3$ improves the metal dispersion and the pre-reforming activity. The reformates from the current pre-reformer contain mainly CH_4, CO, H_2, in which CH_4 can be further converted to H_2 and CO by subsequent main-reforming.

08/02325 Thermal and electrical energy management in a PEMFC stack – an analytical approach

Pandiyan, S. *et al. International Journal of Heat and Mass Transfer*, 2008, 51, (3–4), 469–473.

An analytical method has been developed to differentiate the electrical and thermal resistance of the PEM fuel cell assembly in the fuel cell operating conditions. The usefulness of this method lies in the determination of the electrical resistance based on the polarization curve and the thermal resistance from the mass balance. This method also paves way for the evaluation of cogeneration from a PEMFC power plant. Based on this approach, the increase in current and resistance due to unit change in temperature at a particular current density has been evaluated. It was observed that the internal resistance of the cell is dependent on the electrode fabrication process, which also play a major role in the thermal management of the fuel cell stack.

15 ENVIRONMENT

Pollution, health protection, applications

08/02326 Conceptual differences between the bioclimatic urbanism for Europe and for the tropical humid climate

Corbella, C. D. and Magalhães, M. A. A. A. *Renewable Energy*, 2008, 33, (5), 1019–1023.

This article makes part of a series of conceptual papers to continue the discussion about how architecture and urbanism interact with climate, in tropical regions. Students engaged in normal courses of architecture in tropical regions, particularly in South America, develop their knowledge based on concepts generated in the developed countries – usually related to cold environments. Consequently, these students acquire wrong ideas about urban design of open spaces. Integrating urbanism and climate in tropical countries is still very incipient as an approach and many lecturers reject it, since they prefer to continue with a more formal one, dictated by most of the dominant countries. The herein paper underlines several different concepts and perspectives that separate the two conceptions, leading to a reflection about the subject.

08/02327 Emissions from the combustion of polystyrene, styrene and ethylbenzene under diverse conditions

Ergut, A. *et al. Fuel*, 2007, 86, (12–13), 1789–1799.

This experimental study contrasts the products of incomplete combustion (PIC) of polystyrene, a widespread solid waste, with those from the combustion of its predominant pyrolysate, styrene. The study also included ethylbenzene, as it has been reported to convert to styrene extensively and extremely fast in combustion conditions. Emissions were compared from: (i) steady-state combustion of vaporized ethylbenzene in premixed flames, (ii) steady-state combustion of polystyrene powders in a drop-tube furnace, (iii) batch combustion of fixed beds of polystyrene in a muffle furnace, and (iv) batch combustion of pools of liquid styrene in a muffle furnace. PICs, sampled in post-combustion zones, included unburned hydrocarbons, with emphasis to polycyclic aromatic hydrocarbons (PAH), particulates, CO_2 and CO. Yields of major PIC were compared to underscore the differences in the underlying physics of premixed and non-premixed (diffusion) flames. Combustion of polystyrene and styrene in diffusion flames generated soot at any nominal global (bulk) equivalence ratio, no matter how fuel-rich or fuel-lean. On the other hand, combustion of ethylbenzene in premixed flames did not generate any soot up to its soot onset limit, which typically occurs well within the fuel-rich domain. However, conditions that were not conducive to the formation of soot did not preclude the presence of other PIC, such as PAH.

08/02328 Emissions trading beyond Europe: linking schemes in a post-Kyoto world

Anger, N. *Energy Economics*, 2008, 30, (4), 2028–2049.

This paper assesses the economic impacts of linking the EU emissions trading scheme (ETS) to emerging schemes beyond Europe in the presence of a post-Kyoto agreement in 2020. Numerical simulations with a multi-country equilibrium model of the global carbon market show that linking the European ETS induces only minor economic benefits. As trading is restricted to energy-intensive companies that are assigned high initial emissions, the major compliance burden is carried by the non-trading industries excluded from the linked ETS. In the presence of parallel government trading under a post-Kyoto Protocol, the burden of the excluded sectors can be substantially alleviated by international permit trade at the country level. However, the parallel carbon markets of linked ETS companies and post-Kyoto governments are still separated here. From an efficiency perspective, the most desirable future climate policy regime is thus represented by a joint trading system facilitating international emissions trading between ETS companies and post-Kyoto governments. While the clean development mechanism is not able to attenuate the inefficiencies within linked ETS, in a parallel or joint trading regime the economy-wide access to project-based abatement options in developing countries induces large additional cost-savings.

08/02329 Estimating the uncertainty of damage costs of pollution: a simple transparent method and typical results

Spadaro, J. V. and Rabl, A. *Environment Impact Assessment Review*, 2008, 28, (2–3), 166–183.

Whereas the uncertainty of environmental impacts and damage costs is usually estimated by means of a Monte Carlo calculation, this paper shows that most (and in many cases all) of the uncertainty calculation involves products and/or sums of products and can be accomplished with an analytic solution which is simple and transparent. The authors present the assessment of the component uncertainties and calculate the total uncertainty for the impacts and damage costs of the classical air pollutants; results for a Monte Carlo calculation for the dispersion part are also shown. The distribution of the damage costs is approximately lognormal and can be characterized in terms of geometric mean μ_g and geometric standard deviation σ_g, implying that the confidence interval is multiplicative. It is found that for the classical air pollutants σ_g is approximately 3 and the 68% confidence interval is $[\mu_g/\sigma_g, \mu_g\,\sigma_g]$. Because the lognormal distribution is highly skewed for large σ_g, the median is significantly smaller than the mean. The authors also consider the case where several lognormally distributed damage costs are added, for example to obtain the total damage cost due to all the air pollutants emitted by a power plant, and it is found that the relative error of the sum can be significantly smaller than the relative errors of the summands. Even though the distribution for such sums is not exactly lognormal, a simple lognormal approximation is presented that is quite adequate for most applications.

08/02330 Fate and identification of oil-brine contamination in different hydrogeologic settings

Whittemore, D. O. *Applied Geochemistry*, 2008, 22, (10), 2099–2114.

Past disposal of oil-field brine at the surface has caused substantial contamination of water resources in Kansas. Natural saline water occurs in and discharges from Permian bedrock in parts of the state, and other anthropogenic sources of saline water exist, requiring clear identification of different sources. Water-level declines from pumping have increased the lateral migration rate of the saltwater contamination in the aquifer towards water-supply wells. The period of flushing most of the surface-disposed saltwater from the area of shale and limestone bedrock is on the order of many decades but is at least many centuries for the deeper parts of the High Plains aquifer.

08/02331 Fate of mercury and chlorine during SRF co-combustion

Hilber, T. *et al. Fuel*, 2007, 86, (12–13), 1935–1946.

Within the scope of the European Demonstration project RECOFUEL the behaviour and fate of chlorine and mercury during co-combustion of solid recovered fuel (SRF) was investigated in detail, focusing on the environmental compatibility, and based on a lab-scale approach. In this context the term co-combustion describes the thermal utilization of pre-treated waste-derived fuels such as SRF in industrial furnaces or power plants as a supplemental fuel. Following the definitions of the European initiative on SRF standardization CEN/TC 343, these kind of fuels have to be produced from non-hazardous bio-residues, mixed- and mono waste streams. It is one of the key aspects of the production process to reduce the content of waste-borne pollutants such as chlorine or heavy metals. Nonetheless, the efficiency of the production process is limited and the residual pollutant concentrations may exceed those of coal to a certain extent. The experiments, focusing both on chlorine and mercury, indicated that the co-combustion process increases the flue gas concentration of gaseous chlorine species, primarily hydrogen chloride, as a result of waste-borne chlorine. Furthermore, significant differences were observed for ash-bound chlorine, which cannot be explained with the increased chlorine concentration in the gas phase alone. Considering the trace element mercury, increased chlorine inputs did not necessarily lead to increased ionic mercury shares. Furthermore, no or only insignificant amounts of gaseous elemental mercury Hg^0 (g) could be determined downstream the fly ash filter system, while residual $HgCl_2$ (g) concentrations do not differ significantly.

08/02332 How long can excess pollution persist? The non-cooperative case

Hénin, P.-Y. and Schubert, K. *Resource and Energy Economics*, 2008, 30, (2), 277–293.

This paper describes a world composed of two (groups of) countries, which derive their utility from a polluting activity and from the enjoyment of a common environmental quality. The initial situation is both suboptimal and unsustainable: pollution leads to a continuous deterioration of environmental quality. The two countries have heterogeneous preferences for the environment, which are private knowledge. This prevents the adoption of abatement policies negotiated between the two countries, because each one has a strong incentive to announce in every negotiation an arbitrarily low preference for the environment. The two countries then engage in a war of attrition, each of them postponing abatement policies, in the hope that the other will concede first and abate more. The authors study for how long the adjustment is postponed, according to initial conditions, the greenness of the greenest country, the possible range of preferences and the rates of discount and natural regeneration.

08/02333 Inhalation intake fraction of pollutants from episodic indoor emissions

Nazaroff, W. W. *Building and Environment*, 2008, 43, (3), 269–277.

The intake fraction is the attributable pollutant mass inhaled by an exposed population per unit mass released from a source. In this paper, mathematical models are combined with empirical data to explore how intake fraction varies with governing parameters for episodic indoor pollutant releases, such as those from cleaning, cooking, or smoking. Broadly, the intake fraction depends on building-related factors (e.g. ventilation rate), occupant factors (e.g. occupancy), and pollutant dynamic factors (e.g. sorption). In the simple case of the episodic release of a nonreactive pollutant into a well-mixed indoor space with steady occupancy and constant ventilation and breathing rates, the intake fraction is the ratio of the occupants' volumetric breathing rate to the building's ventilation flow rate. Factors such as incomplete mixing, time-varying occupancy, and sorptive interactions modify this basic relationship.

08/02334 International energy assistance needs and options for the Democratic People's Republic of Korea (DPRK)

Von Hippel, D. F. *et al. Energy Policy*, 2008, 36, (2), 541–552.

Recent agreements between the Democratic People's Republic of Korea (DPRK) and the other countries involved in the six-party talks on the future of the DPRK's nuclear weapons program have focused attention on the North Korean energy sector, and, specifically, what the international community can or should do to assist the DPRK in energy sector redevelopment. During two visits to North Korea in 1998 and 2000, a team of American and North Korean researchers conducted a unique rural energy use survey in a flood-affected rural village in the DPRK – the farming village of Unhari. The information gathered during the survey has important implications on how to properly approach the ongoing rural energy crisis in the DPRK, and, more broadly, to provide overall energy sector assistance. The results of the Unhari survey are described briefly, followed by suggestions of internal policy and legal reforms, approaches to international cooperation, key and attractive energy sector technologies and processes for energy sector redevelopment in the DPRK.

08/02335 International technology-oriented agreements to address climate change

de Coninck, H. *et al. Energy Policy*, 2008, 36, (1), 335–356.

Much discussion has surrounded possible alternatives for international agreements on climate change, particularly post-2012. Among these alternatives, technology-oriented agreements (TOAs) are perhaps the least well defined. The author explore what TOAs may consist of, why they might be sensible, which TOAs already exist in international energy and environmental governance, and whether they could make a valuable contribution to addressing climate change. It is found that TOAs aimed at knowledge sharing and coordination, research, development, or demonstration could increase the overall efficiency and effectiveness of international climate cooperation, but are likely to have limited environmental effectiveness on their own. Technology-transfer agreements are likely to have similar properties unless the level of resources expended is large, in which case they could be environmentally significant. Technology-specific mandates or incentives could be environmentally effective within the applicable sector, but are more likely to make a cost-effective contribution when viewed as a complement to rather than a substitute for flexible emissions-based policies. These results indicate that TOAs could potentially provide a valuable contribution to the global response to climate change. The success of specific TOAs will depend on their design, implementation, and the role they are expected to play relative to other components of the policy portfolio.

08/02336 Management of complex knowledge in planning for sustainable development: the use of multi-criteria decision aids

Kain, J.-H. and Söderberg, H. *Environment Impact Assessment Review*, 2008, 28, (1), 7–21.

There lies great potential in methods that facilitate the evaluation of strategies for infrastructural development across multiple knowledge areas, so-called multi-criteria decision aids (MCDAs). In the present article, observations from six case studies are discussed, where the common denominators are infrastructural planning, multi-stakeholder participation and the use of MCDAs as interactive decision support. Three MCDAs are discussed – NAIADE, SCA and STRAD – with an emphasis on how they function in their procedural context. Accordingly, the focus is on MCDAs as actor systems, not as expert systems. The analysis is carried out across four main themes: (a) symmetrical management of different forms of knowledge; (b) management of heterogeneity, pluralism and conflict; (c) functionality and ease of use; and (d) transparency and trust. It shows that STRAD, by far, seems to be the most useful MCDA in interactive settings. NAIADE and SCA are roughly equivalent but have their strengths and weaknesses in different areas. It was found that some MCDA issues require further attention, i.e. regarding transparency and understandability; qualitative/quantitative knowledge input; switching between different modes of weighting; software flexibility; as well as graphic and user interfaces.

08/02337 Modeling and prediction of ventilation methane emissions of U.S. longwall mines using supervised artificial neural networks

Karacan, C. Ö. *International Journal of Coal Geology*, 2008, 73, (3–4), 371–387.

Methane emissions from a longwall ventilation system are an important indicator of how much methane a particular mine is producing and how much air should be provided to keep the methane levels under statutory limits. Knowing the amount of ventilation methane emission is also important for environmental considerations and for identifying opportunities to capture and utilize the methane for energy production. Prediction of methane emissions before mining is difficult since it depends on a number of geological, geographical, and operational factors. This study proposes a principle component analysis (PCA) and artificial neural network (ANN)-based approach to predict the ventilation methane emission rates of U.S. longwall mines. Ventilation emission data obtained from 63 longwall mines in 10 states for the years between 1985 and 2005 were combined with corresponding coalbed properties, geographical information, and longwall operation parameters. The compiled database resulted in 17 parameters that potentially impacted emissions. PCA was used to determine those variables that most influenced ventilation emissions and were considered for further predictive modelling using ANN. Different combinations of variables in the data set and network structures were used for network training and testing to achieve minimum mean square errors and high correlations between measurements and predictions. The resultant ANN model using nine main input variables was superior to multilinear and second-order non-linear models for predicting the new data. The ANN model predicted methane emissions with high accuracy. It is concluded that the model can be used as a predictive tool since it includes those factors that influence longwall ventilation emission rates.

08/02338 Neutronics, activation and waste management of the Candor experiment

Zucchetti, M. *et al. Annals of Nuclear Energy*, 2007, 34, (9), 687–692.

The paper examines the neutronics and activation of Candor, a proposed design evolution of Ignitor in the direction of a device using a DHe fuel cycle. The main characteristics of the Candor machine are described. Activation calculations were done with two codes: ANITA and FISPACT. A comparison of the results for the two codes is carried out. Finally, the paper draws some conclusion on the radioactive waste management options for Candor. No Candor spent material will need to be disposed of as permanent waste in underground repositories. All materials may be recycled, if convenient, after a short interim decay. Concerning clearance, the structure may be declassified after less than 50 years of decay. For magnets, about 100 years of interim decay are necessary. Candor does reach the zero-waste option, without the need of any materials selection, low-activation materials, or further shielding. The final design of a fusion power plant with DHe3 plasmas has yet to be conceived. However, the zero-waste option is a reachable goal for such reactors, as the results for Candor have indicated.

08/02339 Severe accident risks in fossil energy chains: a comparative analysis

Burgherr, P. and Hirschberg, S. *Energy*, 2008, 33, (4), 538–553.

Accidents in the energy sector have been identified as one of the main contributors to man-made disasters. The present work focuses on the assessment of severe accident risks relating to fossil energy chains. Evaluations were based on the highly comprehensive Energy-related Severe Accident Database, which was established at the Paul Scherrer Institut. The historical experience represented in this database allows a detailed comparison of severe accident risks in the broader energy sector. The analyses are not limited to power plants, but cover full energy chains, showing that immediate fatality rates are much higher for full fossil chains than expected if only power plants are considered. The different energy chains were analysed separately, addressing selected technical aspects of severe accidents, followed by comparative evaluations. Generally, immediate fatality rates are significantly lower for countries of the Organization for Economic Co-operation and Development (OECD) and European Union 25 countries (EU25) than for non-OECD countries. In addition to aggregated values, frequency–consequence curves are also provided, since they not only reflect implicitly a ranking based on aggregated values, but also include information such as the maximum credible extent of damages.

08/02340 The evaluation of safety behaviors in a gas treatment company in Iran

Nouri, J. *et al. Journal of Loss Prevention in the Process Industries*, 2008, 21, (3), 319–325.

The study aims to evaluate workers' safety behaviour in an Iranian gas treatment company. The methodology was based on the safety behaviour sampling (SBS) technique. After specifying the unsafe behaviours and with reference to the results of a pilot study, a sample of 3248 was determined, with a sampling accuracy of 5% and confidence level of 95%. The results indicated that 26.7% of workers' behaviours were unsafe. The most important unsafe behaviours were awkward postures in working hours with 13.1% of total unsafe behaviours. The results also notified a significant relationship between age and job experience on unsafe behaviours ($p < 0.001$). The relationship between unsafe behaviours and previous accidents records was also significant ($p < 0.005$). The ultimate findings of the study showed that a considerable number of workers' behaviours were unsafe, which is one of the main antecedents of industrial accidents. Considering catastrophic consequences of accidents in gas treatment industry, the results emphasize on diminishing unsafe behaviours and recommend applying behaviour-based safety principles.

08/02341 The income–pollution relationship and the role of income distribution: an analysis of Swedish household data

Brännlund, R. and Ghalwash, T. *Resource and Energy Economics*, 2008, 30, (3), 369–387.

The main purpose of this study is to analyse the relationship between pollution and income at household level. The study is motivated by the recent literature emphasizing the importance of income distribution for the aggregate relation between pollution and income. The main findings from previous studies are that if the individual pollution–income relationship is non-linear, then aggregate pollution for, say, a whole country, will depend not only on average income, but also on how income is distributed. TThe authors formulate a model for determining the choice of consumption of goods in different types of household. They then link the demand model to emission functions for various goods. The theoretical analysis shows that without imposing very restrictive assumptions on preferences and the emission functions, it is not possible to determine *a priori* the slope or the curvature of the pollution–income relation. The empirical analysis shows that, given the model used, the pollution–income relation has a positive slope in Sweden and is strictly concave for all three pollutants under study (CO_2, SO_2, NO_x), at least in the neighbourhood of the observed income for an average household. The authors also show that altering the prevailing income distribution, holding average income constant, will affect aggregate emissions in the sense that an equalization of incomes will give rise to an increase in emissions. One implication is then that the development of aggregate pollution due to growth depends not only on the income level, but also on how growth is distributed.

08/02342 The Triptych approach revisited: a staged sectoral approach for climate mitigation

den Elzen, M. *et al. Energy Policy*, 2008, 36, (3), 1107–1124.

The Triptych approach is a method for allocating future greenhouse gas (GHG) emission reductions among countries under a post-2012 international climate mitigation regime based on technological criteria at the sector level, and accounting for structural differences. The emission allowances are decomposed according to sectors, thereby enabling the link to real-world emission reduction strategies to be more concrete. The new Triptych approach presented here is a refinement of an earlier version in terms of an increased transparency and allowing a delayed participation for developing countries (initial participation of developing countries with incentives but no penalties through 'no lose' targets or sustainable development policies and measures). For this article the authors calculated the emission reductions for countries for two technology-oriented scenarios, which stabilize GHG concentrations at 450 and 550 ppm CO_2-eq, respectively. The reductions are ambitious, but nonetheless compatible with existing technical reduction potentials as growth is allowed but efficiency has to be improved.

08/02343 Waste gas emission control and constraints of energy and economy in China

Liang, D. and Zhou, Y. *Energy Policy*, 2008, 36, (1), 268–279.

This paper studies the characteristics of waste gas emission (WGE), energy consumption (EC) and economic development in China, and analyses the reason for the change of waste gas intensity (WI) in order to provide necessary information for policy-makers. This paper considers the situation of WGE and the primary factors in China in general to describe the relationship among energy, economy and environmental at the national level. Then the authors detect the main sectors for WGE that have a notable effectiveness for economic and EC through the comparison of the percentage of EC, value added and industrial WGE from combustion in 39 industrial sectors. Then with the calculation of energy intensity, clean level (CL) and WI, this paper selects those crucial sectors for waste gas control and shows the efficiency of waste gas control in these sectors from 2001 to 2005. The results showed most waste gas came from heavy industrial sectors. However, heavy industrial sectors usually have lower CL than light industries. Moreover, within these sectors, some sectors, particularly production and supply of electric power and heat power, showed the tendency of worsening efficiency for waste gas control from 2001 to 2005.

CO_2, NO_x, SO_2 and particulate emissions

08/02344 Analysis of the international distribution of per capita CO_2 emissions using the polarization concept

Duro, J. A. and Padilla, E. *Energy Policy*, 2008, 36, (1), 456–466.

The concept of polarization is linked to the extent that a given distribution leads to the formation of homogeneous groups with opposing interests. This concept, which is basically different from the traditional one of inequality, is related to the level of inherent potential conflict in a distribution. The polarization approach has been widely applied in the analysis of income distribution. The extension of this approach to the analysis of international distribution of CO_2 emissions is quite useful as it gives a potent informative instrument for characterizing the state and evolution of the international distribution of emissions and its possible political consequences in terms of tensions and the probability of achieving agreements. In this paper, the international distribution of per capita CO_2 emissions between 1971 and 2001 is analysed through the adaptation of the polarization concept and measures. It is found that the most interesting grouped description deriving from the analysis is a two groups' one, which broadly coincide with Annex B and non-Annex B countries of the Kyoto Protocol, which shows the power of polarization analysis for explaining the generation of groups in the real world. The analysis also shows a significant reduction in international polarization in per capita CO_2 emissions between 1971 and 1995, but not much change since 1995, which might indicate that polarized distribution of emission is still one of the important factors leading to difficulties in achieving agreements for reducing global emissions.

08/02345 Comparison of CO_2 emission scenarios and mitigation opportunities in China's five sectors in 2020

Cai, W. *et al. Energy Policy*, 2008, 36, (3), 1181–1194.

This study has been created in order to better inform climate policy recommendations for China through the study of emissions reduction potential and mitigation opportunities in the major emission sectors in the country. The LEAP model along with three scenarios has been employed in this study. The study has projected that under all scenarios, China's emissions in major sectors will increase. However, through the current sustainable development strategy and even more aggressive emission reduction policies, an annual average of 201–486 million metric tons (MMT) of emissions could be reduced. The cost analysis shows that opportunities are available to achieve significant additional emission reductions at reasonable rates. Besides the results on mitigation opportunities in each sector, this research also explores sectoral preference when determining policies from different perspectives. This study concludes that China's 'unilateral actions' since 2000 should be recognized and encouraged. If further emission reduction were required, sector-based mitigation policies would be a very good option and selecting proper policy-making perspective(s) and identifying the most cost-effective mitigation measures within sector and across sectors would be the key information needed to devise these policies.

08/02346 CQUESTRA, a risk and performance assessment code for geological sequestration of carbon dioxide

LeNeveu, D. M. *Energy Conversion and Management*, 2008, 49, (1), 32–46.

A computationally efficient semi-analytical code, CQUESTRA, has been developed for probabilistic risk assessment and rapid screening of potential sites for geological sequestration of carbon dioxide. The rate of dissolution and leakage from a trapped underground pool of carbon dioxide is determined. The trapped carbon dioxide could be mixed with hydrocarbons and other components to form a buoyant phase. The program considers potential mechanisms for escape from the geological formations such as the movement of the buoyant phase through failed seals in wellbores, the annulus around wellbores and through open fractures in the caprock. Plume animations of dissolved carbon dioxide in formation water around the wellbores are provided. Solubility, density and viscosity of the buoyant phase are determined by equations of state. Advection, dispersion, diffusion, buoyancy, aquifer flow rates and local formation fluid pressure are taken into account in the modeling of the carbon dioxide movement. Results from a hypothetical example simulation based on data from the Williston basin near Weyburn, Saskatchewan, indicate that this site is potentially a viable candidate for carbon dioxide sequestration. Sensitivity analysis of CQUESTRA indicates that criteria such as siting below aquifers with large flow rates and siting in reservoirs having fluid pressure below the pressure of the formations above can promote complete dissolution of the carbon dioxide during movement toward the surface, thereby preventing release to the biosphere. Formation of very small carbon dioxide bubbles within the fluid in the wellbores can also lead to complete dissolution.

08/02347 Effect of process parameters on power requirements of vacuum swing adsorption technology for CO_2 capture from flue gas

Zhang, J. *et al. Energy Conversion and Management*, 2008, 49, (2), 346–356.

This study focuses on the effects of process and operating parameters – feed gas temperature, evacuation pressure and feed concentration – on the performance of carbon dioxide vacuum swing adsorption (CO_2VSA) processes for CO_2 capture from gas, especially as it affects power consumption. To obtain reliable data on the VSA process, experimental work was conducted on a purposely built three bed CO_2VSA pilot plant using commercial 13X zeolite. Both six-step and nine-step cycles were used to determine the influences of temperature, evacuation pressure and feed concentration on process performance (recovery, purity, power and corresponding capture cost). A simple economic model for CO_2 capture was developed and employed herein. Through experiments and analysis, it is found that the feed gas temperature, evacuation pressure and feed concentration have significant effects on power consumption and CO_2 capture cost. The data demonstrate that the CO_2VSA process has good recovery (>70%), purity (>90%) and low power cost (4–10 kW/TPDc) when operating with 40 °C feed gas provided relatively deep vacuum is used. Enhanced performance is obtained when higher feed gas concentration is fed to the plant, as expected. The data indicates large potential for application of CO_2VSA to CO_2 capture from flue gas.

08/02348 Heat optimisation of a staged gas–solid mineral carbonation process for long-term CO_2 storage

Zevenhoven, R. *et al. Energy*, 2008, 33, (2), 362–370.

Carbonation of magnesium silicates offers an interesting option for CO_2 emission mitigation in Finland, a country with large resources of serpentine-type minerals. Wet processes using aqueous solutions show reasonable chemical kinetics combined with poor energy economy. A dry, gas–solid process with slower chemical kinetics (demonstrated previously), but better energy economy could be an alternative. This paper addresses the energy economy of a two- or three-stage gas–solid process for magnesium silicate carbonation. It involves production of reactive magnesium as magnesium oxide or hydroxide in an atmospheric pressure step, followed by carbonation at elevated pressures that allow for reasonable carbonation reaction kinetics under conditions where magnesium carbonate is thermodynamically stable. For a feasible large-scale process the kinetics in the individual reactors must be fast enough, while the heat produced in the carbonation step must be sufficient to compensate for energy inputs to the preceding step(s). Results give reactor temperature combinations that allow for operation at a negative or zero energy input, for given carbonation reactor pressure and degree of carbonation conversion, and other process energy requirements. Softwares used were HSC and Aspen Plus. Also, some results from gas–solid kinetics studies with magnesium oxide-based materials at the pressures considered are included.

08/02349 Influence of European passenger cars weight to exhaust CO_2 emissions

Zervas, E. and Lazarou, C. *Energy Policy*, 2008, 36, (1), 248–257.

The increase of atmospheric CO_2 concentration influences climate changes. The road transport sector is one of the main anthropogenic sources of CO_2 emissions in the European Union (EU). One of the main parameters influencing CO_2 emissions from passenger cars (PCs) is their weight, which increases during last years. For the same driving distance, heavier vehicles need more work than lighter ones, because they have to move an extra weight, and thus more fuel is consumed and thus increased CO_2 emissions. The weight control of new PCs could be an efficient way to control their CO_2 emissions. After an analysis of the EU new PCs market, their segment distribution and their weight, some estimations for 2020 are presented. Based on this analysis, 13 base scenarios using several ways for the control of the weight of future European new PCs are used to estimate their CO_2 emissions and the benefit of each scenario. The results show that a significant benefit on CO_2 emissions could be achieved if the weight of each PC does not exceed an upper limit, especially if this limit is quite low. The benefit obtained by limitations of weight is higher than the benefit obtained from the expected decreased future fuel consumption. Similar results are obtained when the weight of new PCs does not exceed an upper limit within each segment, or when the weight of each new PC decreases.

08/02350 Numerical simulation of supercritical CO_2 injection into subsurface rock masses

Sasaki, K. *et al. Energy Conversion and Management*, 2008, 49, (1), 54–61.

Carbon dioxide (CO_2) is considered to be one of the greenhouse gases that may contribute most to global warming on the earth. Disposal of CO_2 from stationary sources into subsurface structures has been suggested as a possible means for reducing CO_2 emissions into the atmosphere. However, much remains to be done in the issues regarding the safety and reliability of CO_2 geological sequestration. In this study, a simulation code has been developed by using the mathematical model of two phase flow in porous media to analyse the flow dynamics in the subsurface. The equation of state for CO_2 covering the fluid region from the triple point to the supercritical region is employed to model the states of CO_2 gas, liquid and supercritical state. The correct understanding of the CO_2 state under the geological formation condition is an important factor to predict the injection pressure and CO_2 fluid permeation because the fluid density has a great effect on the injection behaviour. The numerical simulation was implemented under several geological conditions including gas, liquid and supercritical states to examine the optimal injection condition. Comparing the numerical results obtained using the equation of state for CO_2 with those obtained using the ideal gas equation, it has been shown that the difference in the injection pressure appears to be significant near the condition of the critical point of CO_2 and the phase equilibrium curves between the gas and liquid states. The numerical simulation has been implemented to examine the effect of the reservoir condition on the injection behaviour. The injection pressure is decreased at the lower reservoir temperature and higher hydrostatic pressure condition. The CO_2 permeation is also strongly affected by the reservoir condition, and the spatial CO_2 saturation becomes higher with increasing reservoir temperature. It has been demonstrated that the simulation code developed in this study may be useful to provide knowledge required to select the reservoir condition for CO_2 geological sequestration.

08/02351 On the fair division of greenhouse gas abatement cost

Böhringer, C. and Helm, C. *Resource and Energy Economics*, 2008, 30, (2), 260–276.

This paper introduces a solution for the fair division of emission reduction costs in the climate change regime. The primary focus is on the fair division of efficiency gains that arise from exchanging the initial allocation of emission entitlements, rather than the initial allocation itself. The authors propose to complement the competitive Walrasian solution with welfare bounds, the ethical justification of which rests on commonality of ownership. Simulations with an intertemporal computable general equilibrium model illustrate the relevance of such welfare bounds. For a wide range of initial allocations of emission entitlements – including an equal per capita allocation – it is found that developing countries should be fully compensated for their emission abatement efforts, but should not receive any further transfers.

08/02352 Potentials and costs of carbon dioxide mitigation in the world's buildings

Ürge-Vorsatz, D. and Novikova, A. *Energy Policy*, 2008, 36, (2), 642–661.

Buildings are responsible for over a third of global energy-related carbon dioxide (CO_2) emissions. A significant share of these emissions can be avoided cost effectively through improved energy efficiency, while providing the same or higher level of energy services. How large is this emission reduction potential globally and how much will it cost for society to unlock it? This paper provides answers to these questions, presenting the results of bottom-up research conducted for the Intergovernmental Panel on Climate Change (IPCC), based on the assessment of 80 country- or regional-level mitigation studies throughout the world. First, the paper analyses the findings of these studies in a common framework. Then, it aggregates their results into a global estimate of CO_2 mitigation potential. The paper concludes that by 2020 it is possible to cut cost effectively approximately 29% of buildings-related global CO_2 emissions, the largest among all sectors reported by the IPCC, representing a 3.2 $GtCO_2$eq. reduction. Developing countries house the largest cost-effective potential with up to 52% of building-level emissions, whereas transition economies and industrialized countries have cost-effective potentials of up to 37% and 25%, respectively. Energy-efficient lighting was identified as the most attractive measure worldwide, in terms of both reduction potential and cost effectiveness. If this potential is realized, the building-related CO_2 emissions would stay constant over 2004–2030. These stabilization levels (if achieved by all other sectors) would cancel about 3°C temperature increase over the projected period of time.

08/02353 Price drivers and structural breaks in European carbon prices 2005–2007

Alberola, E. *et al. Energy Policy*, 2008, 36, (2), 787–797.

This article aims at characterizing the daily price fundamentals of European Union Allowances (EUAs) traded since 2005 as part of the Emissions Trading Scheme (ETS). The presence of two structural changes on April 2006 following the disclosure of 2005 verified emissions and on October 2006 following the European Commission announcement of stricter Phase II allocation allows to isolate distinct fundamentals evolving overtime. The results extend previous literature by showing that EUA spot prices react not only to energy prices with forecast errors, but also to unanticipated temperatures changes during colder events. Besides, the sub-period decomposition of the pilot phase gives a better grasp of institutional and market events that drive allowance price changes.

08/02354 Taming of the few – the unequal distribution of greenhouse gas emissions from personal travel in the UK

Brand, C. and Boardman, B. *Energy Policy*, 2008, 36, (1), 224–238.

Greenhouse gas emissions from personal transport have risen steadily in the UK. Yet, surprisingly little is known about who exactly is contributing to the problem and the extent to which different groups of the population will be affected by any policy responses. This paper describes an innovative methodology and evaluation tool for profiling annual greenhouse gas emissions from personal travel across all modes of travel. A case study application of the methodology involving a major survey of UK residents provides an improved understanding of the extent to which individual and household travel activity patterns, choice of transport mode, geographical location, socio-economic and other factors impact on greenhouse gas emissions. Air and car travel dominate overall emissions. Conversely, land-based public transport accounts for a very small proportion of emissions on average. There is a highly unequal distribution of emissions amongst the population, independent of the mode of travel, location and unit of analysis. The top 10% of emitters are responsible for 43% of emissions and the bottom 10% for only 1%. Income, economic activity, age, household structure and car availability significantly influence emissions levels. Key policy implications of the results are discussed. The paper concludes by suggesting potential applications of the methodology and evaluation tool.

08/02355 The application of FLOX/COSTAIR technologies to reduce NO_x emissions from coal/biomass fired power plant: a technical assessment based on computational simulation

Wang, Y. D. *et al. Fuel*, 2007, 86, (14), 2101–2108.

Nitrogen oxides (NO_x) is one of the harmful emissions from power plants. Efforts are made to reduce NO_x emissions by researchers and engineers all the times. NO_x emissions are from three resources during the combustion: prompt NO, fuel NO and thermal NO. The last one – thermal NO, which is described by 'Zeldovich-mechanism', is the main source for NO_x emissions. The thermal NO emission mainly results from the high combustion temperature in the combustion process. In order to control the NO formation, the control of peak combustion temperature is the key factor, as well as the oxygen concentration in the combustion areas. Flameless oxidation (FLOX) and continuous staged air combustion (COSTAIR) are two relatively new technologies to control the combustion temperature and the reaction rate and consequently to control the NO_x emissions.In this study both FLOX and COSTAIR technologies are assessed based on a 12 MW_e, coal-fired, circulating fluidized bed combustion (CFBC) power plant by using ECLIPSE simulation software, together with a circulating fluidized bed gasification (CFBG) plus normal burner plant. Two different fuels – coal and biomass (straw) are used for the simulation. The technical results from the study show that the application of FLOX technology to the plant may reduce NO_x emissions by 90% and the application of COSTAIR technology can reduce NO_x emissions by 80–85% from the power plant. The emissions from the straw-fuelled plants are all lower than that of coal-fuelled ones although with less plant efficiencies.

08/02356 Trojan horse or horn of plenty? Reflections on allowing CCS in the CDM

de Coninck, H. *Energy Policy*, 2008, 36, (3), 929–936.

The discussion around allowing CO_2 capture and geological storage (CCS) into the Kyoto Protocol's Clean Development Mechanism (CDM) is important, as the CDM is currently the only structural incentive for reducing greenhouse gas emissions in the developing world. Without the potential incentives given by the CDM, CCS in developing countries will only take place sporadically in niche sectors. The debate around CCS in the CDM has developed into a highly polarized discussion, with a deep divide between proponents and opponents and no view on reconciliation between the various perspectives. Environmental organizations and several developing-country parties in the climate negotiations are increasingly vehemently opposed against CCS in the CDM, and industrialized countries, several large fossil-fuel-dependent developing countries and industry view CCS as a natural option under the CDM, provided some surmountable technical and procedural barriers are taken care of. This paper argues that the efforts of those trying to bring the discussion to a close by solving technical and procedural issues around CCS in the CDM will not lead to agreement because of underlying convictions of all stakeholders. Six convictions are identified and discussed. Based on the discussion of the convictions of both opponents and proponents, research needs and a potential negotiation package are suggested. The research needs are primarily in the field of the CDM market impacts of CCS, the issue of enhanced oil emission accounting, and sustainable development aspects, and particularly whether developing countries could actually benefit from technological leadership in the field of CCS, or whether they will be worse off. Devoting attention to the identified convictions could provide information for a more acceptable negotiation package on CCS in the CDM.

Hydrocarbon emissions

08/02357 A parametric study on the emissions from an HCCI alternative combustion engine resulting from the auto-ignition of primary reference fuels

Machrafi, H. *et al. Applied Energy*, 2008, 85, (8), 755–764.

The homogeneous charge compression ignition is an alternative combustion technology that can reduce automobile pollution, provided that the exhaust emission can be controlled. A parametric study can be useful in order to gain more understanding in the emission reduction possibilities via this new combustion technology. For this purpose, the inlet temperature, the equivalence ratio and the compression ratio are changed, respectively, from 30 to 70 °C, 0.28 to 0.41 and 6 to 14. Also the diluting, thermal and chemical effects of exhaust gas recirculation were studied. The emission of CO, CO_2, O_2 and hydrocarbons has been measured using primary reference fuels. It appears that an increase in the inlet temperature, the EGR temperature, the equivalence ratio and the compression ratio results into a decrease of the emissions of CO and the hydrocarbons of up to 75%. The emission of CO_2 increased, however, by 50%. The chemical parameters showed more complicated effects, resulting into a decrease or increase of the emissions, depending on whether the overall reactivity increased or not. If the reactivity increased, generally, the emissions of CO and hydrocarbons increased, while that of CO_2 increased. The increase of CO_2 emissions could be compensated by altering the compression ratio and the EGR parameters, making it possible to control the emission of the HCCI engine.

08/02358 Evaluation of the conversion efficiency of ceramic and metallic three way catalytic converters

Santos, H. and Costa, M. *Energy Conversion and Management*, 2008, 49, (2), 291–300.

Ceramic and metallic three way catalytic converters have been compared to assess the influence of the substrate geometrical and physical parameters on the exhaust gas conversions for several vehicle-operating conditions. Both catalysts were placed on a vehicle equipped with a 2.8 l DOHC V6 spark ignition engine that was tested on a chassis dynamometer under steady state conditions for several engine speeds and loads. The data obtained include exhaust gas species concentrations and temperature taken both upstream and downstream of the catalytic converter, as well as temperatures in various locations within the substrate of the catalysts. The experimental data revealed that: (i) at low space velocities, the ceramic substrate presents better conversions, particularly for HC and CO, as compared to the metallic substrate, possibly because of its lower thermal conductivity which facilitates local ignition; (ii) at high space velocities, the metallic substrate presents better conversions, as compared to the ceramic substrate, mainly because of its larger geometric surface area and lower transverse Peclet number; and (iii) in general, the HC conversion for small space velocities is kinetically controlled while for high space velocities it is mass transfer limited; both limitations are less pronounced for the CO conversion and insignificant for the NO_x conversion.

08/02359 Measurements of dioxin emissions during co-firing in a fluidised bed

Gulyurtlu, I. *et al. Fuel*, 2007, 86, (14), 2090–2100.

The emissions of dioxins could be considerable when fuels with high chlorine content are used, particularly in fluidized beds due to constraints to use temperatures in the range 800–900 °C for other considerations. However, mixing of fuels with different characteristics may lead to a reduction in dioxin emissions. Studies are currently being undertaken at the above-mentioned department in mixing fuels of varying chlorine and sulfur contents to monitor the emissions of dioxins both in the gas and solid phases. Furthermore, the influence of certain elements like Cu in the ash in the emissions of dioxins is also studied to verify the catalytic effect. The INETI pilot-scale test facility is used for the combustion work. Two different coals, namely Colombian and Polish, are used as the base fuel. The supplementary fuels for co-firing include MBM and straw pellets. The combustion temperature is maintained at about 800–830 °C range without any limestone addition. The residence time of over 2 s is respected. Results obtained by far suggest that the presence of sulfur in both fuels have a very strong effect on the eventual emissions of dioxins and the synergy regarding to reduce the dioxins below the levels permitted is possible by mixing fuels based on their characteristics. The paper reports the results obtained and evaluates the effect of fuel nature and operating conditions on the emissions of dioxins.

Life cycle analysis

08/02360 A thermodynamic, environmental and material flow analysis of the Italian highway and railway transport systems

Federici, M. *et al. Energy*, 2008, 33, (5), 760–775.

The goal of this work is to provide a multi-method multi-scale comparative picture of selected terrestrial transport modalities. This is achieved by investigating the Italian transportation system by means of four different evaluation methods: material flow accounting, embodied energy analysis, exergy analysis and emergy synthesis. The case study is the main Italian transportation infrastructure, composed by highways, railways, and high-speed railways (high-speed trains, HST) sub-systems supporting both passengers and freight transport. All the analyses have been performed based on a common database of material, labor, energy and fuel input flows used in the construction, maintenance and yearly use of roads, railways and vehicles. Specific matter and energy intensities of both passenger and freight transportation services were calculated factors affecting results as well as strength and weakness points of each transportation modality were also stressed. Results pointed out that the most important factors in determining the acceptability of a transportation system are not only the specific fuel consumption and the energy and material costs of vehicles, as it is common belief, but also the energy and material costs for infrastructure construction as well as its intensity of use (with special focus on load factor of vehicles). The latter become the dominant factors in HST modality, due to technological and safety reasons that require high energy-cost materials and low intensity of traffic. This translates into very high thermodynamic and environmental costs for passenger and freight transported, among which an embodied energy demand up to 1.44 MJ/p-km and 3.09 MJ/t-km, respectively.

08/02361 Estimating the pre-harvest greenhouse gas costs of energy crop production

Clair, S. S. *et al. Biomass and Bioenergy*, 2008, 32, (5), 442–452.

Full greenhouse gas (GHG) life-cycle analysis of bio-energy production chains is often constrained by a lack of information on pre-harvest GHG costs and emissions during production of the energy crop. In this paper, the authors assessed pre-harvest GHG costs of production of short rotation coppice (SRC), *Miscanthus* and oil seed rape (OSR: for liquid bio-fuel production) when compared to a range of former land-use baselines. It was found that GHG costs are very low for *Miscanthus* and SRC but higher for OSR production, determined mainly by the need for nitrogen fertilization. Compared to baseline land uses, SRC and *Miscanthus* have much lower GHG costs than arable cropping or intensively managed grasslands, with OSR production having similar GHG costs to arable cropping. Establishing broadleaved forests have low GHG costs, but 5-year GHG costs of *Miscanthus* and SRC are similar to forest. It is shown that former land use is of critical importance when determining if energy crops are a net source or sink of GHGs. Converting to SRC and *Miscanthus* are the most favourable energy crops in terms of GHG savings. Converting to OSR from arable cropping results in either small increases or decreases in GHG emissions, depending upon the former tillage practice on the arable land, but replacing either broadleaved woodland with OSR (mainly due to soil carbon loss and increased fertilizer-related N_2O emissions), or grassland with OSR (mainly due to loss of soil carbon), greatly increases emissions. Policies to maximize GHG benefits from energy crops should encourage that they be established preferentially on croplands.

08/02362 Life cycle analysis of UK coal fired power plants

Odeh, N. A. and Cockerill, T. T. *Energy Conversion and Management*, 2008, 49, (2), 212–220.

This paper examines the life cycle GHG emissions from existing UK pulverized coal power plants. The life cycle of the electricity generation plant includes construction, operation and decommissioning. The operation phase is extended to upstream and downstream processes. Upstream processes include the mining and transport of coal including methane leakage and the production and transport of limestone and ammonia, which are necessary for flue gas clean up. Downstream processes, on the other hand, include waste disposal and the recovery of land used for surface mining. The methodology used is material based process analysis that allows calculation of the total emissions for each process involved. A simple model for predicting the energy and material requirements of the power plant is developed. Preliminary calculations reveal that for a typical UK coal fired plant, the life cycle emissions amount to 990 g CO_2-e/kWh of electricity generated, which compares well with previous UK studies. The majority of these emissions result from direct fuel combustion (882 g/kWh, 89%) with methane leakage from mining operations accounting for 60% of indirect emissions. In total, mining operations (including methane leakage) account for 67.4% of indirect emissions, while limestone and other material production and transport account for 31.5%. The methodology developed is also applied to a typical IGCC power plant. It is found that IGCC life cycle emissions are 15% less than those from PC power plants. Furthermore, upon investigating the influence of power plant parameters on life cycle emissions, it is determined that, while the effect of changing the load factor is negligible, increasing efficiency from 35% to 38% can reduce emissions by 7.6%. The current study is funded by the UK National Environment Research Council and is undertaken as part of the UK Carbon Capture and Storage Consortium (UKCCSC). Future work will investigate the life cycle emissions from other power generation technologies with and without carbon capture and storage. The current paper reveals that it might be possible that, when CCS is employed, the emissions during generation decrease to a level where the emissions from upstream processes (i.e. coal production and transport) become dominant, and so, the life cycle efficiency of the CCS system can be significantly reduced. The location of coal, coal composition and mining method are important in determining the overall impacts. In addition to studying the net emissions from CCS systems, future work will also investigate the feasibility and techno-economics of these systems as a means of carbon abatement.

08/02363 Life cycle assessment (LCA) of PET bottles and comparative LCA of three disposal options in Mauritius

Foolmaun, R. K. and Ramjeawon, T. *International Journal of Environment and Waste Management*, 2008, 2, (1–2), 125–138.

Disposal of the increasing volume of used polyethylene terephthalate (PET) bottles has been a cause for concern for the Mauritian government. To assist the government in decision-making, a study on PET bottles and its disposal was undertaken using the life cycle assessment tool. Three disposal scenarios, namely (100%) landfilling; (100%) incineration; and 50% landfilling and 50% incineration were compared. Sima Pro 5.1 software was used to analyse data and eco-indicator 99 method was used for the impact assessment. The results showed that about 90% of the total environmental impact happened during the assembly and use phase of PET bottles. Of the disposal options, 100% incineration was found to be the most preferred option.

08/02364 Life cycle cost analysis of HPVT air collector under different Indian climatic conditions

Raman, V. and Tiwari, G. N. *Energy Policy*, 2008, 36, (2), 603–611.

In this communication, a study is carried out to evaluate an annual thermal and exergy efficiency of a hybrid photovoltaic thermal (HPVT) air collector for different Indian climate conditions, of Srinagar, Mumbai, Jodhpur, New Delhi and Banglore. The study has been based on electrical, thermal and exergy output of the HPVT air collector. Further, the life cycle analysis in terms of cost/kWh has been carried out. The main focus of the study is to see the effect of interest rate, life of the HPVT air collector, subsidy, etc. on the cost/kWh HPVT air collector. A comparison is made keeping in view the energy matrices. The study reveals that (i) annual thermal and electrical efficiency decreases with increase in solar radiation and (ii) the cost/kWh is higher in case of exergy when compared with cost/kWh on the basis of thermal energy for all climate conditions. The cost/kWh for climate conditions of Jodhpur is most economical.

08/02365 Life cycle simulation-based economic and risk assessment of biomass-based fuel ethanol (BFE) projects in different feedstock planting areas

Yu, S. and Tao, J. *Energy*, 2008, 33, (3), 375–384.

Increasing attention is being paid to biomass-based fuel ethanol (BFE) for its contributions to moderating oil crisis, reducing environmental impact, and promoting local economy. This paper aims to assess and compare the economic viabilities and investment risks of three BFE projects in different feedstock planting areas in China. Internal cost models of wheat-based fuel ethanol (WFE) in Central China, corn-based fuel ethanol (CFE) in Northeast China, and cassava-based fuel ethanol (KFE) in Southwest China are developed. The projects' net cash flow (NCF) and net present values (NPV) are pursued by internal cost model simulation with the Monte Carlo method. According to the simulation results, KFE project is economically viable for its positive expected NPV and its expected internal rate of return (12%), while CFE and WFE are not economically viable for their negative expected NPVs. Sensitivity analysis is performed to find out the key determinants of the projects' expected NPVs and to evaluate their future economic viabilities. The analysis results indicate that CFE has better potential to become economically viable comparing to WFE project. Possible measures to improve the expected NPV of CFE are then proposed.

08/02366 Life-cycle assessment of straw use in bio-ethanol production: a case study based on biophysical modelling

Gabrielle, B. and Gagnaire, N. *Biomass and Bioenergy*, 2008, 32, (5), 431–441.

Cereal straw, a by-product in the production of agricultural crops, is considered as a potentially large source of energy supply with an estimated value of 47×10^{18} J worldwide. However, there is some debate regarding the actual amounts of straw which could be removed from arable soils without jeopardizing their quality, as well as the potential trade-offs in the overall straw-to-energy chain compared to the use of fossil energy sources. Here, a deterministic model of C and N dynamics was used in soil-crop systems to simulate the effect of straw removal under various sets of soil, climate and crop management conditions in northeastern France. Model results in terms of nitrate leaching, soil C variations, nitrous oxide and ammonia emissions were subsequently input into the life-cycle assessment (LCA) of a particular bio-energy chain in which straw was used to generate heat and power in a plant producing bio-ethanol from wheat grains. Straw removal had little influence on simulated environmental emissions in the field, and straw incorporation in soil resulted in a sequestration of only 5–10% of its C in the long term (30 years). The LCA concluded to significant benefits of straw use for energy in terms of global warming and use of non-renewable energy. Only the eutrophication and atmospheric acidification impact categories were slightly unfavourable to straw use in some cases, with a difference of 8% at most relative to straw incorporation. These results based on a novel methodology thereby confirm the environmental benefits of substituting fossil energy with straw.

08/02367 Performance, emission and economic assessment of clove stem oil–diesel blended fuels as alternative fuels for diesel engines

Mbarawa, M. *Renewable Energy*, 2008, 33, (5), 871–882.

In this study the performance, emission and economic evaluation of using the clove stem oil (CSO)–diesel blended fuels as alternative fuels for diesel engine have been carried out. Experiments were performed to evaluate the impact of the CSO–diesel blended fuels on the engine performance and emissions. The societal life cycle cost (LCC) was chosen as an important indicator for comparing alternative fuel operating modes. The LCC using the pure diesel fuel, 25% CSO and 50% CSO–diesel blended fuels in diesel engine are analysed. These costs include the vehicle first cost, fuel cost and exhaust emissions cost. A complete macroeconomic assessment of the effect of introducing the CSO–diesel blended fuels to the diesel engine is not included in the study. Engine tests show that performance parameters of the CSO–diesel blended fuels do not differ greatly from those of the pure diesel fuel. Slight power losses, combined with an increase in fuel consumption, were experienced with the CSO–diesel blended fuels. This is due to the low heating value of the CSO–diesel blended fuels. Emissions of CO and HC are low for the CSO–diesel blended fuels. NO_x emissions were increased remarkably when the engine was fuelled with the 50% CSO–diesel blended fuel operation mode. A remarkable reduction in the exhaust smoke emissions can be achieved when operating on the CSO–diesel blended fuels. Based on the LCC analysis, the CSO–diesel blended fuels would not be competitive with the pure diesel fuel, even though the environmental impact of emission is valued monetarily. This is due to the high price of the CSO.

08/02368 Thermodynamic limitations to nuclear energy deployment as a greenhouse gas mitigation technology

Pearce, J. M. *International Journal of Nuclear Governance, Economy and Ecology*, 2008, 2, (1), 113–130.

To both replace fossil-fuel-energy use and meet the future energy demands, nuclear energy production would have to increase by 10.5% per year from 2010 to 2050. This large growth rate creates a cannibalistic effect, where nuclear energy must be used to supply the energy for future nuclear power plants. This study showed that the limit of ore grade to offset greenhouse gas emissions is significantly higher than the purely thermodynamic limit set by energy payback times found in the literature. In addition, any use of nuclear energy directly contributes heat to the Earth, which the Earth must radiate into space by raising its temperature to maintain thermodynamic equilibrium. This is a relatively small effect, but as energy consumption grows it must be considered for a world powered by nuclear energy. This results of this study demand modesty in claims of 'emission-free nuclear energy' as a panacea for global climate destabilization.

16 ENERGY

Supplies, policy, economics, forecasts

08/02369 A critical review of IEA's oil demand forecast for China

Nel, W. P. and Cooper, C. J. *Energy Policy*, 2008, 36, (3), 1096–1106.

China has a rapidly growing economy with a rapidly increasing demand for oil. The International Energy Agency (IEA) investigated possible future oil demand scenarios for China in the 2006 World Energy Outlook. The debate on whether oil supplies will be constrained in the near future, because of limited new discoveries, raises the concern that the oil industry may not be able to produce sufficient oil to meet this demand. This paper examines the historical relationship between economic growth and oil consumption in a number of countries. Logistic curve characteristics are observed in the relationship between per capita economic activity and oil consumption. This research has determined that the minimum statistical (lower-bound) annual oil consumption for developed countries is 11 barrels per capita. Despite the increase reported in total energy efficiency, no developed country has been able to reduce oil consumption below this lower limit. Indeed, the IEA projections to 2030 for the OECD countries show no reduction in oil demand on a per capita basis. If this lower limit is applied to China, it is clear that the IEA projections for China are under-estimating the growth in demand for oil. This research has determined that this under-estimation could be as high as 10 million barrels per day by 2025. If proponents of Peak Oil such as Laherrère, Campbell and

Deffeyes are correct about the predicted peak in oil production before 2020 then the implications of this reassessment of China's oil demand will have profound implications for mankind.

08/02370 A decision support system to compare different strategies for achieving the Italian Kyoto Protocol commitment

Beccali, G. *et al. International Journal of Nuclear Governance, Economy and Ecology*, 2008, 2, (1), 28–62.

In order to meet the Italian Kyoto Protocol commitment, in 2002 the Interministerial Committee for Economic Planning (CIPE) approved the national allocation plan for the reduction of greenhouse gases (GHGs), envisioning various alternative scenarios. In this paper an extended impact assessment of the plan is accomplished and some further options are conceived and analysed in order to find an optimal trade-off among the different economic, environmental and social items at stake. After the selection of a set of independent indicators, nine different scenarios for the GHG reductions were evaluated and they were sorted according to the principles of the multicriteria analysis. The results of the evaluation process show that the preferable options are also the ones realizing a good compromise between economic investment and reduction of GHG emissions. Although the model is necessarily affected by some subjective choices, it has a high level of transparency and scientific reliability.

08/02371 America's bottom-up climate change mitigation policy

Lutsey, N. and Sperling, D. *Energy Policy*, 2008, 36, (2), 673–685.

Many diverse actions can be taken to reduce greenhouse gas (GHG) emissions. Increasingly in the United States, policy-makers at sub-national levels are setting emission targets and implementing plans for sector-specific GHG reductions. In this paper, local, state, and regional policy actions in the USA are inventoried and analysed as to their potential effect on national emissions. The realization of all existing sub-national initiatives, as of September 2007, could stabilize US emissions at 2010 levels by the year 2020. The scale of these many decentralized mitigation actions, and their tendency to follow consistent steps, provide a counterpoint to oft-cited drawbacks of decentralized environmental policy. It also indicates that the US has been more committed to climate change mitigation than is generally acknowledged.

08/02372 Applying physical input–output tables of energy to estimate the energy ecological footprint (EEF) of Galicia (NW Spain)

Penela, A. C. *et al. Energy Policy*, 2008, 36, (3), 1148–1163.

Nowadays, the achievement of sustainable development constitutes an important constraint in the design of energy policies, being necessary the development of reliable indicators to obtain helpful information about the use of energy resources. The ecological footprint (EF) provides a referential framework for the analysis of human demand for bioproductivity, including energy issues. In this article, the theoretical bases of the footprint analysis are described by applying input–output tables of energy to estimate the Galician energy ecological footprint (EEF). It is concluded that the location of highly polluting industries in Galicia makes the Galician EEF quite higher than more developed regions of Spain. The relevance of the outer component of the Galician EEF is also studied. First, available information seems to indicate that the energy incorporated to the trading of manufactured goods would notably increase the Galician consumption of energy. On the other hand, the inclusion of electricity trade in the EEF analysis, including an adjustment, following the same philosophy as with manufactured goods is proposed. This adjustment would substantially reduce the Galician EEF, as the exported electricity widely exceeds the imported one.

08/02373 Bin weather data for 38 Greek cities

Papakostas, K. *et al. Applied Energy*, 2008, 85, (10), 1015–1025.

Ambient temperature bin data are used for estimating the energy consumption for heating and cooling of buildings. This well-known method is a steady-state approach and the energy requirements are determined at various outdoor temperatures, in order to account for the effect of outside temperature on the HVAC equipment efficiency. The application of the method requires detailed bin data. In this paper, the dry-bulb temperature bin data for 38 Greek cities are determined by using a reliable estimating methodology, based on monthly-average outdoor temperatures and solar clearness index. The data are calculated from −18 °C to 42 °C with 2 °C increments in six daily 4-h shifts, and are presented in tabular form.

08/02374 Biodiesel options in Greece

Panoutsou, C. *et al. Biomass and Bioenergy*, 2008, 32, (6), 473–481.

Following a European Directive (2003/30/EC) on the promotion of the use of biofuels or other renewable fuels for transport dated May 2003, the Greek government recently conducted a study on biofuels in Greece as part of the national report for the Directive. According to this, biodiesel will be the main biofuel for the Greek transport sector with bioethanol playing a much more minor role. The amount of biodiesel required to satisfy the indicative target of 2% (on a lower calorific basis) for the year 2005 is estimated to be ca. 42,560 tonnes, while the amount to satisfy the indicative target of 5.75% for the year 2010 is estimated to be ca. 135,585 tonnes. This paper will analyse the resources available for biodiesel production and identify the most realistic options under technical, economic and environmental perspectives.

08/02375 Bioenergy transition in rural China: Policy options and co-benefits

Gan, L. and Yu, J. *Energy Policy*, 2008, 36, (2), 531–540.

This paper reviews the current situation of bioenergy development in China, particularly on its relationship to sustainable rural development. It argues that the current government strategy, investment policy and industrial interest are over-emphasized on biomass-burning power generation as part of the clean energy development trajectories, which may not lead to the most cost-effective outcomes in terms of investments, resource use and social development objectives. It points out that there are large potentials in developing and disseminating household-based biomass technologies in rural areas, especially with energy-efficient modern biomass stoves, which can produce far more economic, social and environmental benefits than biomass power plants. It is a decentralized solution to use renewable energy resources for meeting multi-objectives. It is suggested that key incentive policies be provided by the government to encourage this technological transition, or the leapfrogging from using traditional household stoves towards modern biomass stoves, which will lead to a win–win situation in global, regional and local environmental protection, sustainable resource management and related social benefits, particularly for the poor in remote communities. Six policy recommendations are made: (1) financial schemes development; (2) preferable tax and carbon tax; (3) regulatory policy reform; (4) service industry support; (5) market research, training and capacity building for key stakeholders; (6) development of methodologies and standards for CDM projects. The potential co-benefits brought up by this massive biomass technology transition will bring new perspectives to realizing Millennium Development Goals (MDGs) and global CO_2 emissions reduction targets in China, and also set an example to other developing countries.

08/02376 Choice and design of regulatory instruments in the presence of green consumers

Bansal, S. *et al. Resource and Energy Economics*, 2008, 30, (3), 345–368.

Using a vertically differentiated product model, this paper examines welfare implications of various government policies in a situation where consumers are environmentally discerning. It studies *ad valorem* taxes/subsidies and emission taxes. The optimal policy depends on the magnitude of damage parameter associated with environmental externality. For a given distribution of tastes and preferences, as the damage parameter increases from a low to a high value, the optimal policy shifts from an ad valorem tax to an ad valorem subsidy. It also shows that for a sufficiently low damage parameter, an ad valorem tax dominates an emission tax.

08/02377 Decision support tools for advanced energy management

Marí, K. *et al. Energy*, 2008, 33, (6), 858–873.

Rising fuel costs boost energy prices, which is a driving force for improving efficiency of operation of any energy generation facility. This paper focuses on enhancing the operation of distributed integrated energy systems (IES), system that bring together all forms of cooling, heating and power technologies. Described methodology can be applied in power generation and district heating companies, as well as in small-scale systems that supply multiple types of utilities to consumers in industrial, commercial, residential and governmental spheres. Dispatching of such system in an optimal way needs to assess large number of production and purchasing schemes in conditions of continually changing market and variable utility demands influenced by many external factors, very often by weather conditions. The paper describes a combination of forecasting and optimization methods that supports effective decisions in IES system management. The forecaster generates the future most probable utility demand several hours or days ahead, derived from the past energy consumer behaviour. The optimizer generates economically most efficient operating schedule for the IES system that matches these forecasted energy demands and respects expected purchased energy prices.

08/02378 E85 and fuel efficiency: an empirical analysis of 2007 EPA test data

Roberts, M. C. *Energy Policy*, 2008, 36, (3), 1233–1235.

It is well known that ethanol has less energy per unit volume than gasoline. Differences in engine design and fuel characteristics affect the efficiency with which the chemical energy in gasoline and ethanol is converted into mechanical energy, so that the change in fuel economy may not be a linear function of energy content. This study analyses the fuel economy tests performed by the US Environmental Protection Agency (EPA) on 2007 model year E85-compliant vehicles and finds that the difference in average fuel economy is not statistically different from the differential in energy content.

08/02379 Electricity demand for Sri Lanka: a time series analysis

Amarawickrama, H. A. and Hunt, L. C. *Energy*, 2008, 33, (5), 724–739.
This study estimates electricity demand functions for Sri Lanka using six econometric techniques. It shows that the preferred specifications differ somewhat and there is a wide range in the long-run price and income elasticities with the estimated long-run income elasticity ranging from 1.0 to 2.0 and the long-run price elasticity from 0 to -0.06. There is also a wide range of estimates of the speed with which consumers would adjust to any disequilibrium, although the estimated impact income elasticities tended to be more in agreement ranging from 1.8 to 2.0. Furthermore, the estimated effect of the underlying energy demand trend varies between the different techniques; ranging from being positive to zero to predominantly negative. Despite these differences, the forecasts generated from the six models up until 2025 do not differ significantly. It is therefore encouraging that the Sri Lanka electricity authorities can have some faith in econometrically estimated models used for forecasting. Nonetheless, by the end of the forecast period in 2025 there is a variation of around 452 MW in the base forecast peak demand that, in relative terms for a small electricity generation system like Sri Lanka's, represents a considerable difference.

08/02380 Electricity reform in Argentina: lessons for developing countries

Pollitt, M. *Energy Economics*, 2008, 30, (4), 1536–1567.
Argentina was one of the first countries in the world to implement a comprehensive reform of its electricity sector. Among developing countries only Chile has had a comparably comprehensive and successful reform. This paper traces the history of the Argentine reform, which began in 1992, and assesses its progress and its lessons. The authors conclude that the reform was very successful prior to the collapse of the Argentine peso in early 2002. Lessons are suggested for the generation, transmission and distribution (and retailing) sectors, as well as the economic regulation of electricity and the general institutional environment. It was noted that the achievements of the sector have been severely strained by the government's poor energy policy since the crisis.

08/02381 Emergy synthesis and simulation for Macao

Lei, K. and Wang, Z. *Energy*, 2008, 33, (4), 613–625.
Macao is a tourist city with a dense population and has a shortage of natural resources. Almost all of the city's life-support systems thus depend on imports of external resources. During the past 20 years, Macao has experienced an economic boom accompanied by rapid social development, in which the gambling industry and related tourism services have become the main economic activity. This paper employs emergy flow analysis to investigate and characterize the evolution and development of Macao from 1983 to 2003. In addition, Macao has experienced six periods of land reclamation since 1866, supported by large-scale importation of sand and rocks from China. By simulating the emergy trends using the STELLA dynamic modeling software, it was predicted that the evolution of Macao's development and trends in the coming 20 years. In 2025, the city's economy is estimated to be 15 times its current size as a result of Macao's territorial expansion. The exported emergy will increase slowly and then stabilize, the population will reach 593 185, and the area covered by Macao will expand to 38.91 km^2.

08/02382 Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data

Lee, C.-C. and Chang, C.-P. *Resource and Energy Economics*, 2008, 30, (1), 50–65.
This paper applies the most recently developed panel unit root, heterogeneous panel cointegration and panel-based error correction models to re-investigate co-movement and the causal relationship between energy consumption and real GDP within a multivariate framework that includes capital stock and labor input for 16 Asian countries during the 1971–2002 period. It employs the production side model (aggregate production function). The empirical results fully support a positive long-run cointegrated relationship between real GDP and energy consumption when the heterogeneous country effect is taken into account. It is found that although economic growth and energy consumption lack short-run causality, there is long-run unidirectional causality running from energy consumption to economic growth. This means that reducing energy consumption does not adversely affect GDP in the short-run but would in the long-run; thus, these countries should adopt a more vigorous energy policy. Furthermore, the investigation is broadened by dividing the sample countries into two cross-regional groups, namely the APEC and ASEAN groups, and even more important results and implications emerge.

08/02383 Energy consumption and economic growth in Turkey during the past two decades

Balat, M. *Energy Policy*, 2008, 36, (1), 118–127.
The Turkish economy has undergone a transformation from agricultural to industrial, enhanced by rapid urbanization, especially after 1982. Turkey's gross national production has grown at an average annual rate of 5% since 1983, ranking it at the top of the OECD countries, although the growth pattern has been uneven. Economic growth in recent years has been associated with the privatization of public enterprises. Turkey's energy demand has risen rapidly as a result of social and economic development. The country's energy consumption has grown considerably since the beginning of the 1980s. The Turkish government encourages foreign and Turkish private sector investors to implement the energy projects and is currently working on a new investment model for the construction of new generation plants to create the additional capacity needed. The Turkish energy sector, with its current size of 30 billion US dollars and projected size of 55 billion US dollars by 2015, as well as the fundamental restructuring process it has been going through since 2001, attracts both local and foreign investors. The sector needs an investment amount of approximately 130 billion US dollars by 2020. The aim of the present paper is to investigate the increasing of Turkish energy demand with the growth of the economy and utilization of domestic energy sources and the case of investments and imports in Turkey during the past two decades.

08/02384 Energy crops in Ireland: an economic comparison of willow and *Miscanthus* production with conventional farming systems

Styles, D. *et al. Biomass and Bioenergy*, 2008, 32, (5), 407–421.
Recent full decoupling of EU agricultural subsidy payments from production in Ireland is forecast to result in substantial destocking of grassland over the coming decade. In conjunction with increased energy prices, this presents new opportunities for energy crops. This paper uses extensive literature review and country-specific information on current prices to construct life-cycle cost assessments for production of *Miscanthus* and short-rotation coppice willow (SRCW) in Ireland. Gross margins for different harvest and supply strategies (e.g. chopped or baled harvest for *Miscanthus*; stick or chipped harvest for SRCW) are calculated based on farm-gate biomass prices equivalent to 70, 100 and 130 € t^{-1} dry matter (DM) at maximum 20% moisture content – reduced for some SRCW supply strategies to reflect additional chipping and transport costs, and lower heating values. These are compared with gross margin projections for conventional agricultural systems (dairy, cattle rearing, 'cattle and other', sugar beet, winter wheat, spring barley and set aside) using a net present value approach. Production costs expressed per tonne DM were similar for *Miscanthus* (€37–48) and SRCW (€31–46). Mid-estimate discounted, annualized gross margins ranging between 326 and € ha^{-1} for *Miscanthus*, and between 211 and 270 € ha^{-1} for SRCW, compared favourably with all conventional agricultural systems considered except dairy. These gross margins were based on peak-productivity combustible yields of 14 and 10 t DM ha^{-1} a^{-1} for *Miscanthus* and SRCW. Yield variation will affect gross margins, but low yields were still calculated to realize positive returns. However, the application of high-activity cost estimates for all energy-crop cultivation activities resulted in negative returns for some supply strategies. Recently announced government support for SRCW and *Miscanthus* considerably reduces investment risk for farmers, whilst utilization of SRCW to treat waste water could substantially increase revenues. Energy crop cultivation has the potential to offer farmers a modestly profitable alternative to declining returns from conventional land uses.

08/02385 Energy performance of building envelopes in different climate zones in China

Yang, L. *et al. Applied Energy*, 2008, 85, (9), 800–817.
Energy performance of office building envelope designs in the five major climate zones – severe cold, cold, hot summer and cold winter, mild, and hot summer and warm winter – in China was investigated. A major city within each climate zone was selected. These were Harbin, Beijing, Shanghai, Kunming and Hong Kong. Generic building envelopes were developed based on data gathered from building surveys, local energy codes and the ASHRAE Standard. The overall thermal transfer value (OTTV) method and the heating degree-days technique were adopted in the analysis. Cooling and heating requirements due to heat gain/loss through the building envelopes were determined based on the respective OTTV parameters and building load coefficients. Different shape coefficients were also considered. For a typical floor, chiller load due to heat gain through the building

envelope varied from 1.0 kW h/m^2 in Kunming to 23.5 kW h/m^2 in Beijing, and the heating load ranged from 2.7 kW h/m^2 in Hong Kong to 124.3 kW h/m^2 in Harbin.

08/02386 Energy potential through agricultural biomass using geographical information system – a case study of Punjab

Singh, J. *et al. Biomass and Bioenergy*, 2008, 32, (4), 301–307.

Agricultural biomass has immense potential for power production in an Indian state like Punjab. A judicious use of biomass energy could potentially play an important role in mitigating environmental impacts of non-renewable energy sources particularly global warming and acid rain. But the availability of agricultural biomass is spatially scattered. The spatial distribution of this resource and the associate costs of collection and transportation are major bottlenecks for the success of biomass energy conversion facilities. Biomass, being scattered and loose, has huge collection and transportation costs, which can be reduced by properly planning and locating the biomass collection centres for biomass-based power plants. Before planning the collection centres, it is necessary to evaluate the biomass, energy and collection cost of biomass in the field. In this paper, an attempt has been made to evaluate the spatial potential of biomass with geographical information system and a mathematical model for collection of biomass in the field has been developed. The total amount of unused agricultural biomass is about 13.73 Mt year^{-1}. The total power generation capacity from unused biomass is approximately 900 MW. The collection cost in the field up to the carrier unit is US\$3.90 t^{-1}.

08/02387 Energy resources and use: the present situation and possible paths to the future

Lior, N. *Energy*, 2008, 33, (6), 842–857.

Recent estimates and forecasts of the oil, gas, coal resources and their reserve/production ratio, nuclear and renewable energy potential, and energy uses are surveyed. The impact of the rapidly growing economies of the highly populated countries, as well as of the concern about global warming, are presented and assessed. A brief discussion of the status and prospects of fossil, nuclear and renewable energy use, and of power generation (including hydrogen, fuel cells, micro power systems, and the futuristic concept of generating power in space for terrestrial use, is given. A brief summary of the energy research effort and budgets in the US, and EU are presented, and ways to resolve the problem of the availability, cost, and sustainability of energy resources alongside the rapidly rising demand are discussed. The author's view of the promising energy research and development (R&D) areas, their potential, foreseen improvements and their time scale, and last year's trends in government funding are presented.

08/02388 Energy taxation in a small, open economy: social efficiency gains versus industrial concerns

Bjertnæs, G. H. and Fæhn, T. *Energy Economics*, 2008, 30, (4), 2050–2071.

Welfare analyses of energy taxes typically show that systems with uniform rates perform better than differentiated systems, especially if revenue can be recycled by cutting taxes that are more distortionary. However, in practical policy, efficiency gains must be traded off against industrial concerns. Presumably, energy-dependent industries of small, open economies will suffer relatively more if taxed. This computable general equilibrium study examines the social costs of compensating the energy-intensive export industries in Norway for their profit losses from imposing the same electricity tax on all industries. The costs are surprisingly modest. This is explained by the role of the Nordic electricity market, which is still limited enough to respond to national energy tax reforms. Thus, an electricity price reduction partly neutralizes the direct impact of the tax on profits. In addition, the authors examine the effects of different compensation schemes and find significantly lower compensation costs when the scheme is designed to release productivity gains.

08/02389 Evaluating the power investment options with uncertainty in climate policy

Yang, M. *et al. Energy Economics*, 2008, 30, (4), 1933–1950.

This paper uses a real options approach (ROA) for analysing the effects of government climate policy uncertainty on private investors' decision-making in the power sector. It presents an analysis undertaken by the International Energy Agency (IEA) that implements ROA within a dynamic programming approach for technology investment choice. Case studies for gas, coal and nuclear power investment are undertaken with the model. Illustrative results from the model indicate four broad conclusions: (i) climate change policy risks can become large if there is only a short time between a future climate policy event such as post-2012 and the time when the investment decision is being made; (ii) the way in which CO_2 and fuel price variations feed through to electricity price variations is an important determinant of the overall investment risk that companies will face; (iii) investment risks vary according to the technology being considered, with nuclear power appearing to be particularly exposed to fuel and CO_2 price risks under various assumptions; and (iv) the government will be able to reduce investors' risks by implementing long-term (say 10 years) rather than short-term (say 5 years) climate change policy frameworks. Contributions of this study include: (1) having created a step function with stochastic volume of jump at a particular time to simulate carbon price shock under a particular climate policy event; (2) quantifying the implicit risk premium of carbon price uncertainty to investors in new capacity; (3) evaluating carbon price risk alongside energy price risk in investment decision-making; and (4) demonstrating ROA to be a useful tool to quantify the impacts of climate change policy uncertainty on power investment.

08/02390 Everybody merges with somebody – the wave of M&As in the energy industry and the EU merger policy

Verde, S. *Energy Policy*, 2008, 36, (3), 1125–1133.

Almost all the main European energy companies have recently shown an unprecedented activism on financial markets and the wave of M&As seems far from being over. A sound understanding of the wave can provide hints on the future developments of the market and the effects on merger policy. These operations are explained by several reasons, ranging from the pan-European players' strategy to the creation of national champions, from the objective to merge gas and electricity businesses (convergence mergers) to the aim of re-building a vertical dimension of the industry after liberalization. In face of such a broad range of motivations, merger policy has to be applied consistently to each case and case-law is developing to better address energy-specific issues. Still, the characteristics of the energy industry may allow for more economic insight and a longer-term perspective in merger cases, in order to guarantee that energy and merger policy are leading to the same objectives, through different tools.

08/02391 Fuel cell systems for transportation: status and trends

Ahluwalia, R. K. and Wang, X. *Journal of Power Sources*, 2008, 177, (1), 167–176.

The US program for the development of direct hydrogen-fuelled automotive fuel cell systems has established ambitious performance and cost targets for the 2010 and 2015 time frames. These targets include peak and rated power efficiencies of 60% and 50%, respectively, specific power and power densities of 650 We kg^{-1} and 650 We L^{-1}, and manufactured costs of \$45 and 30 kWe^{-1} for 80 kWe^{-1} net systems in the 2010 and 2015 systems, respectively. Here, the authors discuss the use of fuel cell system models to examine the performance and projected manufactured costs of 2005 systems and the improvements needed to meet the 2010 and 2015 system level targets. It appears possible to meet most of the 2010 performance targets with advances such as the nano-structured thin film electrocatalysts and a modified electrolyte membrane capable of operating at up to 95 °C, at least for short periods. To meet the 2015 targets, however, the fuel cell systems may need to operate without pressurization at higher temperatures of up to 120 °C without the need to humidify the fuel gas and air, along with several other improvements in stack and balance-of-plant components. The simulations provide quantitative estimates of the various performance and cost parameters of the near-term and the advanced systems that can achieve the targets set for automotive fuel cell system development.

08/02392 Global warming and renewable energy sources for sustainable development in Turkey

Yüksel, I. *Renewable Energy*, 2008, 33, (4), 802–812.

Turkey, with its young population and growing energy demand per person, its fast growing urbanization, and its economic development, has been one of the fast growing power markets of the world for the last two decades. It is expected that the demand for electric energy in Turkey will be 300 billion kWh by the year 2010 and 580 billion kWh by the year 2020. Turkey is heavily dependent on expensive imported energy resources that place a big burden on the economy and air pollution is becoming a great environmental concern in the country. In this regard, renewable energy resources appear to be the one of the most efficient and effective solutions for clean and sustainable energy development in Turkey. Turkey's geographical location has several advantages for extensive use of most of these renewable energy sources. This article presents a review of the potential and utilization of the renewable energy sources in Turkey.

08/02393 Governance of competitive transmission investment in weak institutional systems

Abdala, M. A. *Energy Economics*, 2008, 30, (4), 1306–1320.

Despite progress in economic analysis in recent years, transmission investment governance still poses policy design challenges in competitive electricity systems. The degree of regulatory intervention in allocating investment costs is a central issue. Scholars tend to agree that centralized solutions are almost inevitable, mainly due to free riding and coordination problems. In systems with weak institutional endowments and pressures of distributive politics, however, there is an increased likelihood of regulators acting opportunistically or imposing arbitrary changes to the cost allocation rules, which makes centralized solutions less desirable. The authors provide some examples from Argentina, El Salvador and Peru and suggest that a two-tier governance scheme composed of a self-governing Forum of transmission stakeholders, with regulation as a subsidiary measure, may be a more adequate design to restraint undue government interference. The expected outcome is twofold: a better match with users' preferences and a restraint to government opportunism and arbitrariness. Measuring the robustness of this scheme in minimizing the risks for either too much or too little investment will certainly require further research.

08/02394 Integrated energy planning for transportation sector – a case study for Iran with techno-economic approach

Sadeghi, M. and Hosseini, H. M. *Energy Policy*, 2008, 36, (2), 850–866.
Transportation sectors in developing countries can suffer from ever-increasing energy consumption. Integrated National Energy Planning (INEP) is a possible solution for these countries to alter their suboptimal pattern and rationalize their energy consumption. One of the INEP targets is determining optimal patterns of fuels and transportation technologies to satisfy future demand of freight and passenger transportation at the lowest cost levels. Following the above target, this paper is concerned with the optimal consumption pattern of fuels focusing on vehicle technologies within the next 25 years (up to 2029). Using Energy Flow Optimization Model-ENVironment (EFOM-ENV) model, various steps as designing of 'Reference Energy System (RES)' of the model, data processing and scenario analysis are followed. Based on the modelling results, substitution of urban railroad technologies (subway, LRT and monorail), all of passenger CNG technologies (cars, buses and minibuses), rural railroad freight technologies (electrical, gas oil and LNG freight trains) and finally, CNG and LNG heavy and light trucks with current passenger and freight vehicle technologies are suggested. This scenario will decline fuel consumption by about 14% totally, that the most part of it belongs to gasoline and gas oil (24% and 17%, respectively). Total discounted cost of transportation system will decline from 806.20 to 691.74 billion dollars (14%) during the time horizon.

08/02395 Investment under market and climate policy uncertainty

Fuss, S. *et al. Applied Energy*, 2008, 85, (8), 708–721.
Climate change is considered as one of the major systematic risks for global society in the 21st century. Yet, serious efforts to slow the accumulation of emissions are still in their primordial stage and policy makers fail to give proper long-term signals to emitters. These days, investors do not only face uncertainty from volatile prices in the traditional markets, but also from the less conceivable uncertainty of stricter climate change policy. This paper investigates the impact of learning about the commitment of government to a climate policy regime in a real options framework. Two types of uncertainty are distinguished: market-driven price volatility around a mean price and bifurcating price trajectories mimicking uncertainty about changing policy regimes. One of the findings is that the producer facing market uncertainty about CO_2 prices invests into carbon-saving technology earlier than if the actual price path had been known on beforehand. This is not a typical real options outcome, but the result of optimizing under imperfect information, which leads to decisions that are different from the optimal strategies under full information. On the other hand, policy uncertainty induces the producer to wait and see whether the government will further commit to climate policy. This waiting is a real options effect. In other words, if learning about government commitment is more valuable than investing into mitigation technologies immediately, the option value exceeds the value of the technology and investment will be postponed. This might lead to supply shortages and limited diffusion of less carbon-intensive technology.

08/02396 Low-frequency collection of materials disassembled from end-of-life vehicles On the value of on-line monitoring in optimizing route planning

Krikke, H. *et al. International Journal of Production Economics*, 2008, 111, (2), 209–228.
New European legislation for end-of-life vehicles has led to national car-recycling systems such as Auto Recycling Nederland. Increasingly, these reverse supply chains are under cost pressures but regulation remains firm. Typically, these systems are supply driven and notoriously uncertain due to a lack of information. In this article, an approach to optimize the collection (transportation) of dismantled materials from end-of-life vehicles is presented. Experience from forward supply chain management has shown the potential of joint coordination of transportation and inventory decisions for example. Using new (mandatory installed) information technology, the authors are now able to monitor inventory levels of dismantled materials on distance. A proactive 'look ahead' planning methodology is introduced based on two types of collection orders: 'must' and 'can' orders. Every review period all 'must' orders have to be collected, while 'can' orders are only collected if they can be combined beneficially with 'must' orders. The routing problems are solved by a combination of route generation and set partitioning. The savings potential (value of information) is illustrated in a simulation. The system is illustrated in real-life cases for Auto Recycling Nederland. In several scenarios, the old reactive approach is compared with the proactive approach resulting in cost savings up to 19%.

08/02397 Modeling climate feedbacks to electricity demand: the case of China

Asadoorian, M. O. *et al. Energy Economics*, 2008, 30, (4), 1577–1062.
This paper is an empirical investigation of the effects of climate on the use of electricity by consumers and producers in urban and rural areas within China. It takes advantage of an unusual combination of temporal and regional data sets in order to estimate temperature, as well as price and income elasticities of electricity demand. The estimated positive temperature/electric power feedback implies a continually increasing use of energy to produce electric power which, in China, is primarily based on coal. In the absence of countervailing measures, this will contribute to increased emissions, increased atmospheric concentrations of greenhouse gases, and increases in greenhouse warming.

08/02398 Multi-criteria evaluation of residential energy supply systems

Alanne, K. *et al. Energy and Buildings*, 2007, 39, (12), 1218–1226.
In this paper, the selection of a residential energy supply system is considered as a multi-criteria decision-making problem, which involves both financial and environmental issues. Specifically, the authors compare micro-CHP (micro-cogeneration) heating with traditional heating systems through an evaluation that accounts for: (i) the decision-makers' subjective preferences, (ii) uncertainties in the performance of micro-CHP heating systems (which are partly caused by the lack of long-term operational experiences) and (iii) the context-dependency of life-cycle costs and environmental burdens of heating systems. Motivated by these considerations, the authors employ the PAIRS multi-criteria decision-making methodology that captures incomplete information by way of interval-valued parameters and provides support for sensitivity analyses, too. The comparative analysis of alternative heating systems suggests that micro-CHP is a reasonable alternative to traditional systems, particularly from the environmental point of view.

08/02399 Optimization of energy systems based on evolutionary and social metaphors

Dimopoulos, G. G. and Frangopoulos, C. A. *Energy*, 2008, 33, (2), 171–179.
Optimization problems that arise in energy systems design often have several features that hinder the use of many optimization techniques. These optimization problems have non-continuous mixed variable definition domains, are heavily constrained, are multimodal (i.e. have many local optima) and, foremost, the functions used to define the engineering optimization problem are often computationally intensive. Three methods are tested here: (a) a struggle genetic algorithm (StrGA), (b) a particle swarm optimization algorithm (PSOA), and (c) a PSOA with struggle selection (PSOStr). The last is a hybrid of the evolutionary StrGA and the socially inspired PSOA. They are tested in four purely mathematical and three energy systems thermoeconomic optimization problems. All of the methods solved successfully all the problems. The PSOStr, however, outperformed the other methods in terms of both solution accuracy and computational cost (i.e. function evaluations).

08/02400 Preparing for global rollout: a 'developed country first' demonstration programme for rapid CCS deployment

Gibbins, J. and Chalmers, H. *Energy Policy*, 2008, 36, (2), 501–507.
Carbon dioxide (CO_2) and other greenhouse gases from fossil fuel use in many developed and developing countries are expected to be the major source of anthropogenic emissions for the foreseeable future. As a result, the potential to use CO_2 capture and storage (CCS) for significant reductions in CO_2 emissions from the use of coal (and other fossil fuels) at large point sources could become very important in determining the feasibility of climate change mitigation. Large-scale deployment of CCS in the EU from 2020 has been suggested, but this paper illustrates how time is very short if two complete learning cycles are to be achieved before a possible rollout in the early/mid 2020s. It also highlights some key differences between CO_2 capture technologies that suggest that learning can be achieved more quickly with post-combustion capture than with other options. This might allow rollout to be accelerated by perhaps 5 years for post-combustion capture.

08/02401 Profitability of sparse district heating

Reidhav, R. and Werner, S. *Applied Energy*, 2008, 85, (9), 867–877.

The expansion of district heating into areas of low heat densities (heat sparse areas) constitutes a challenge due to the higher distribution costs. The profitability of sparse district heating has been analysed from actual investments in 74 areas with 3227 one-family houses connected to district heating between 2000 and 2004 in Göteborg, Sweden. The profitability was estimated from a probable price model, a typical marginal heat generation cost, and the investments from the actual connections made. The analysis identified factors as the linear heat density and heat sold per house explaining the main variations in profitability. The profitability analysis was concluded with a competition analysis. The main conclusion is that sparse district heating is possible when reaching low investment costs for the local distribution network and low marginal costs for the heat generation. In Sweden, the general competitiveness of sparse district heating is facilitated by the high consumption taxes for fuel oil, natural gas, and electricity. Hence, it should be more difficult to introduce sparse district heating in other countries with low energy taxes.

08/02402 Prospects for renewable energy for seaborne transportation – Taiwan example

Hua, J. *et al. Renewable Energy*, 2008, 33, (5), 1056–1063.

This paper highlights the need for the development of a renewable infrastructure for marine transportation. The result of a survey performed in this study serves as information for public policy makers on the degree to which policy can or should attempt to provide guidelines and incentives in shaping the attitude or behaviours of the industry towards the application. There is a high degree of preference for renewable over fossil as energy source for both ship power and household electricity. While solar is the most favorable energy type for household electricity, hydrogen combustion (80%) is the most supported alternative for powering commercial shipping. The fuel cell is the next highly favoured (64%) alternative energy that is applied onboard ship as perceived by the Taiwanese maritime industry. The result also indicates that the preference of a specific energy type onboard ship is also based upon other factors such as feasibility rather than the respondents' personal preference.

08/02403 Replacing tedium with transformation: why the US Department of Energy needs to change the way it conducts long-term R&D

Sovacool, B. K. *Energy Policy*, 2008, 36, (3), 923–928.

To avoid promoting technologies that merely produce incremental change, the US Department of Energy needs to establish a new organization designed to focus on transformational R&D projects. From its inception in 1977, the US Department of Energy (DOE) has been responsible for maintaining the nation's nuclear stockpile, leading the country in terms of basic research, setting national energy goals, and managing thousands of individual programs. Despite these responsibilities, however, the DOE research and development (R&D) model does not appear to offer the nation an optimal strategy for assessing long-term energy challenges. American energy policy continues to face constraints related to an overly rigid management structure and loss of mission within the DOE, layers of stove-piping within and between the national laboratories, and inadequate public and private funding for energy R&D. To address these concerns, an independent organization dedicated to transformative, creative energy R&D is required.

08/02404 Resource evaluation of typical energy plants and possible functional zone planning in China

Shao, H. and Chu, L. *Biomass and Bioenergy*, 2008, 32, (4), 283–288.

Energy plants are important resources for bioenergy. China has 1554 species of oil plants, including 154 species with oil content greater than 40% in seeds, and 30 species of shrubs or arbor plants with rich biofuel components. Most of these oil plants grow in the tropical and subtropical zones of China. The richness of oil plants decreases gradually from south to north, from east to west, as well as from lower to higher altitude. This paper focuses on the natural habitats of 10 main biofuel woody plant species and their potential for cultivation under a broad range of environmental conditions. Ecological zoning, availability of the land resources for these plants, and suggestions for developing energy plants were also discussed.

08/02405 Rural electrification in Zambia: a policy and institutional analysis

Haanyika, C. M. *Energy Policy*, 2008, 36, (3), 1044–1058.

Zambia is well endowed with hydropower and other energy resources, which could facilitate production of electricity for both urban and rural areas of the country. The country has an installed electricity generation capacity of 1786 MW and undeveloped hydropower potential of over 6000 MW. In the last few years, demand has been growing and it is anticipated to outstrip supply in 2008. The load growth is attributed to increased mining activities and development of the industrial base. The country is also endowed with abundant natural resources such as arable land, water, minerals and wildlife. With the available resource base, electricity along with other social and economic infrastructure such as roads and telecommunications could facilitate increased economic activities. In rural areas, electricity could be used for crop irrigation, agro-processing, small-scale mining and to facilitate tourism. However, rural electrification (RE) faces many challenges such as long distances from existing power stations to targeted rural areas, low population densities, high poverty levels and low skills availability. These and other factors have contributed to continued low levels of access to electricity in rural areas of the country. Measures so far undertaken to facilitate access to electricity in rural areas of Zambia include the adoption of a new National Energy Policy (NEP) in 1994. With regard to the electricity sector and RE in particular, the NEP was aimed at facilitating increased access by liberalizing and restructuring the electricity market and promoting the use of low-cost technologies and decentralized renewable energies. To facilitate implementation of the new policy, the government established a legal and institutional framework by enacting new legislation, namely, the Electricity Act and the Energy Regulation Act in 1995. The Electricity Act provided for liberalization and regulation of the electricity sector, while the Energy Regulation Act provided for the establishment of an independent regulator so as to stimulate private sector participation and efficiency. In addition, a Rural Electrification Fund (REF) and associated administration mechanism was established in 1995. However, RE continued to experience many challenges. In 2003, the government enacted the Rural Electrification Act leading to the establishment of an agency dedicated to RE. This paper analyses the policy, legal and institutional measures implemented in Zambia and assesses their potential or effectiveness to tackle some of the challenges facing RE in the country so as to increase access and affordability.

08/02406 Second-home electricity consumption

Andersen, F. M. *et al. Energy Policy*, 2008, 36, (1), 280–289.

In Denmark, electricity consumption in first and second homes has developed quite differently. Since 1990, electricity consumption in ordinary residences has grown moderately, while consumption in weekend and second homes has increased considerably. In turn, this development has been blamed on a growing number of luxury cottages, new legislation permitting senior citizens to have their permanent address in their second home and a growing number of electric appliances. In order to examine the growing electricity consumption in second homes and to estimate future demand, a multidisciplinary study combining top-down and bottom-up analyses was conducted, i.e. combining models using aggregated economic parameters and feasibility studies using technical parameters, respectively. The top-down estimation showed that changes in electricity consumption in second homes correlate to changes in income. The bottom-up estimation showed that consumption was mainly affected by the frequency with which second homes were used in the winter time. This indicates that additional second homes, increased full-time use and intensified use of electric appliances are the main reasons for the observed increases in electricity consumption. Luxury tourism use and senior citizens' that use a few per cent of the second homes as their home contribute to a minor degree to the overall increase of electricity consumption. Scenarios show that this development may accelerate with increased leisure time, increased use and more permanent settlement in second homes.

08/02407 Short-term forecasting of Jordanian electricity demand using particle swarm optimization

El-Telbany, M. and El-Karmi, F. *Electric Power Systems Research*, 2008, 78, (3), 425–433.

Short-term electricity demand forecasting (i.e. the prediction of hourly loads (demand) for the next hour to several days out) is one of the most important tools by which an electric utility/company plans and dispatches the loading of generating units in order to meet system demand. The accuracy of the dispatching system, which is derived from the accuracy of the forecasting algorithm used, will determine the economics of the operation of the power system. The inaccuracy or large error in the forecast simply means that load matching is not optimized and consequently the generation and transmission systems are not being operated in an efficient manner. This paper discusses and presents the results of utilizing neural network for forecasting the Jordanian electricity demand that is trained by particle swarm optimization technique, which is a new adaptive algorithm based on a social-psychological metaphor. The results of using this technique are compared with the results of using back-propagation algorithm and autoregressive moving average method.

08/02408 Spatial energy market risk analysis using the semivariance risk measure

Yu, Z. *International Journal of Electrical Power & Energy Systems*, 2007, 29, (8), 600–608.

The paper concentrates on the analysis of semivariance (SV) as a market risk measure for market risk analysis of mean–semivariance (MSV) portfolios. The advantage of MSV over variance as a risk measure is that MSV provides a more logical measure of risk than the MV method. In addition, the relationship of the SV with the lower partial movements is discussed. A spatial risk model is proposed as a basis of risk assessment for short-term energy markets. Transaction costs and other practical constraints are also included. A case study is provided to show the successful application of the model.

08/02409 Stochastic modeling of financial electricity contracts

Benth, F. E. and Koekebakker, S. *Energy Economics*, 2008, 30, (3), 1116–1157.
In this paper, the authors discuss the modelling of electricity contracts traded in many deregulated power markets. These forward/futures type contracts deliver (either physically or financially) electricity over a specified time period, and is frequently referred to as swaps since they in effect represent an exchange of fixed for floating electricity price. The authors propose to use the Heath–Jarrow–Morton approach to model swap prices since the notion of a spot price is not easily defined in these markets. For general stochastic dynamical models, the authors connect the spot price, the instantaneous-delivery forward price and the swap price, and analyse two different ways to apply the Heath–Jarrow–Morton approach to swap pricing: Either one specifies a dynamics for the non-existing instantaneous-delivery forwards and derives the implied swap dynamics, or one models directly on the swaps. The former is shown to lead to quite complicated stochastic models for the swap price, even when the forward dynamics is simple. The latter has some theoretical problems due to a no-arbitrage condition that has to be satisfied for swaps with overlapping delivery periods. To overcome this problem, a practical modelling approach is analysed. The market is supposed only to consist of non-overlapping swaps, and these are modelled directly. A thorough empirical study is performed using data collected from Nord Pool. The investigations demonstrate that it is possible to state reasonable models for the swap price dynamics which is analytically tractable for risk management and option pricing purposes, however, this is an area of further research.

08/02410 Sustainable energy policy indicators: review and recommendations

Patlitzianas, K. D. *et al. Renewable Energy*, 2008, 33, (5), 966–973.
Nowadays, the development of a sustainable indicators' framework towards the sustainable energy policy making should be characterized by clarity and transparency. Even though the energy policy making has been the subject of many researchers, studies proposing an appropriate framework of sustainable indicators that have to be used are not present in the international literature. The purpose of the current paper is to present an integrated review of the methodologies and the related activities of the energy indicators and to recommend an operational framework of appropriate indicators supporting thus the policy makers/analysts/citizens towards a sustainable energy policy making.

08/02411 Taking out 1 billion tons of CO_2: the magic of China's 11th Five-Year Plan?

Lin, J. *et al. Energy Policy*, 2008, 36, (3), 954–970.
China's 11th Five-Year Plan (FYP) sets an ambitious target for energy-efficiency improvement: energy intensity of the country's gross domestic product (GDP) should be reduced by 20% from 2005 to 2010. This is the first time that a quantitative and binding target has been set for energy efficiency, and signals a major shift in China's strategic thinking about its long-term economic and energy development. The 20% energy-intensity target also translates into an annual reduction of over 1.5 billion tons of CO_2 by 2010, making the Chinese effort one of the most significant carbon mitigation efforts in the world today. While it is still too early to tell whether China will achieve this target, this paper attempts to understand the trend in energy intensity in China and to explore a variety of options toward meeting the 20% target using a detailed end-use energy model.

08/02412 The impact of electricity market liberalization in Turkey 'free consumer' and distributional monopoly cases

Bahçe, S. and Taymaz, E. *Energy Economics*, 2008, 30, (4), 1603–1624.
The electricity sector has grown substantially in Turkey since the early 1960s as a result of rapid industrialization and urbanization. The vertically integrated state-owned company had a legally established monopoly on the generation, transmission and distribution of electricity in Turkey. With the support and encouragement of international organizations like the World Bank, Turkey has initiated a comprehensive program to liberalize and privatize the electricity market in 2001. The liberalization of the electricity market in Turkey started in the distribution side of the market. The distribution network was divided into 21 distribution regions and in each of these, separate – initially state-owned – distribution companies have been authorized to distribute and sell electricity. The plan envisaged to complete privatization of all distribution companies until the end of 2006. This study compares the welfare implication of privatization of the distribution networks by comparing two extreme cases, a pure regional distributional monopoly case and a representative pure 'free' consumer case, with a benchmark case of administered price regulation. For this purpose, a simulation model of the Turkish electricity system is developed, and use the data on generation and distribution costs. The simulation analysis shows that substantial welfare losses occur if the distributional companies behave as regional monopolists. The findings reiterate the importance of regulation and market design.

08/02413 The manufacturing base under energy price uncertainty

Alghalith, M. *Energy Economics*, 2008, 30, (4), 1951–1956.
This paper provides empirical and methodological analysis under a very important source of uncertainty: energy price uncertainty. In doing so, the impact of the energy price instability on the US manufacturing output and the manufacturing sector's demand for energy is shown. In addition, the method enables us to easily derive empirical comparative statistics results that can be compared to the theoretical results.

08/02414 The sustainability challenge of meeting carbon dioxide targets in Europe by 2020

Saikku, L. *et al. Energy Policy*, 2008, 36, (2), 730–742.
Following the Kyoto Protocol, the European Union obligated itself to lower its greenhouse gas (GHG) emissions 20% below their 1990 level, by the year 2020. Carbon dioxide is the major GHG. To fulfil this obligation, the nations must meet the sustainability challenge of countering rising population plus affluence with the dematerialization of less energy per GDP plus the decarbonization of less carbon per energy. To test the feasibility of meeting the challenge, the authors analysed carbon dioxide emission during 1993–2004. Although emissions in the entire Union grew only by an average of 0.31% per year, emissions and their drivers varied markedly among the 27 member states. Dematerialization and decarbonization did occur, but not enough to offset the slight population growth plus rapidly increasing affluence. To fulfil its obligation in the next 12 years, the EU27 would have to counter its increasing population and affluence by a combined dematerialization and decarbonization 1.9–2.6 times faster than during 1993–2004. Hence, fulfilling its obligation by addressing fossil carbon emissions alone is very unlikely.

08/02415 Thermal diary: connecting temperature history to indoor comfort

Chun, C. *et al. Building and Environment*, 2008, 43, (5), 877–885.
To explore the relationship between thermal history and indoor comfort, surveys and measurements were conducted in Seoul, Korea and Yokohama, Japan. Fifty-two subjects were recruited from university campuses in Seoul and Yokohama during the hot season in August 2002. To collect information regarding people's daily thermal history, background questions (a thermal diary) were completed by subjects during the 24 h prior to entering in a climate chamber. Subjects changed into uniform clothing ensembles and complete thermal diary questions just prior to entering the chamber which was pre-conditioned to 28 °C and 50% relative humidity. Subjects entered the chamber and completed a set of thermal comfort questions at 10-min intervals for 1 h. Thermal history, prior to the chamber experiment, influenced the thermal sensation in chamber. Though the physical conditions in the climate chamber were identical (28 °C, 50% rh), Yokohama subjects responded with cooler thermal sensations than Seoul subjects. These subjects experienced hotter weather conditions (than the Seoul subjects) and voted that they felt cooler than the Seoul subjects who experienced cooler temperatures prior to entering the chamber. It was also found that subjects who use air-conditioning at home responded with warmer thermal sensations than the subjects who did not use air-conditioning. These results indicate that there is a strong interaction and influence of the experience with outdoor weather and the indoor thermal comfort.

08/02416 Total-factor energy efficiency of regions in Japan

Honma, S. and Hu, J.-L. *Energy Policy*, 2008, 36, (2), 821–833.
This study computes the regional total-factor energy efficiency (TFEE) in Japan by employing the data envelopment analysis (DEA). A dataset of 47 prefectures in Japan for the period 1993–2003 is constructed. There are 14 inputs, including three production factors (labour employment, private, and public capital stocks) and 11 energy sources (electric power for commercial and industrial use, electric power for residential use, gasoline, kerosene, heavy oil, light oil, city gas, butane gas, propane gas, coal, and coke). GDP is the sole output. Following an earliler study by Fukao and Yue, data on private and public capital stocks are extended. All the nominal variables are transformed into real variables, taking into consideration the 1995 price level. For kerosene, gas oil, heavy oil, butane gas, coal, and coke, there are a few

prefectures with TFEEs less than 0.7. The five most inefficient prefectures are Niigata, Wakayama, Hyogo, Chiba, and Yamaguchi. Inland regions and most regions along the Sea of Japan are efficient in energy use. Most of the inefficient prefectures that are developing mainly upon energy-intensive industries are located along the Pacific Belt Zone. A U-shaped relation similar to the environmental Kuznets curve (EKC) is discovered between energy efficiency and per capita income for the regions in Japan.

08/02417 U.S. manufacturing aggregate energy intensity decomposition: The application of multivariate regression analysis

Alghandoor, A. *et al*. *International Journal of Energy Research*, 2008, 32, (2), 91–106.

This paper introduces the use of a multivariate regression analysis to explain factors that impact aggregate energy intensity. This kind of study is useful to evaluate the past and predicts the future trends for energy-policy evaluation. Historical aggregate fuel and electricity intensities of the entire US manufacturing sector (Standard Industrial Classification, SIC, codes of 20–39) over the 1977–1998 period are used to develop the proposed multivariate regression model. The proposed model allows identifying the structural effect of aggregate energy intensity changes without relying on detailed disaggregated energy data. Its results are validated by comparison with those from conventional decomposition techniques based on economic index numbers. For illustration, the historical aggregate fuel intensity of the US primary metal industry (SIC 33) is used as an example of a situation for which economic index numbers fail to decompose the historical aggregate energy intensity since the disaggregated energy data are unavailable, while the multivariate regression analysis can still be applied. Empirical results show that a structural shift contributes to decreases of about 28, 41 and 19% of total declines of US manufacturing aggregate fuel, US manufacturing aggregate electricity, and US primary metal industry aggregate fuel intensities, respectively, for the 1977–1998 period. The method based on multivariate regression models estimates the time series structural effects within deviation averages of 8.5 and 7.0% of the time series structural effect estimates based on the economic index numbers for the U.S. manufacturing aggregate fuel and electricity intensities, respectively, even though the multivariate regression model does not require disaggregated energy data.

Energy conservation

08/02418 Analysis of advanced energy chain typologies

Lund, P. *International Journal of Energy Research*, 2008, 32, (2), 144–153.

A method for estimating the effectiveness and CO_2 emissions of advanced energy conversion systems from primary to final energy is presented. A traditional condensing power plant for electricity production and a fuel boiler for heat production based on natural gas were used as the reference system. Several potentially better energy chains were analysed including CHP, tri-generation, heat pumps and efficiency improvements in final energy use. All above solutions could provide clear reductions in primary energy use and emissions, in most cases tens of per cents, but the results are sensitive to operational conditions. In a heat pump system, the primary energy savings are considerable but emission reductions may turn out to be marginal or even negative whereas in co-generation the emission reductions are higher than energy chain topologies over the reference system even in the less favourable cases.

08/02419 China's energy efficiency target 2010

Yang, M. *Energy Policy*, 2008, 36, (2), 561–570.

The Chinese government has set an ambitious target: reducing China's energy intensity by 20%, or 4.36% each year between 2006 and 2010 on the 2005 level. Real data showed that China missed its target in 2006, having reduced its energy intensity only by 1.3%. The objective of this study is to evaluate the feasibility and potential of the Chinese to achieve the target. This paper presents issues of macro-economy, population migration, energy savings, and energy efficiency policy measures to achieve the target. A top-down approach was used to analyse the relationship between the Chinese economic development and energy demand cycles and to identify the potentials of energy savings in sub-sectors of the Chinese economy. A number of factors that contribute to China's energy intensity are identified in a number of energy-intensive sectors. This paper concludes that China needs to develop its economy at its potential GDP growth rate; strengthen energy efficiency auditing, monitoring and verification; change its national economy from a heavy-industry-dominated mode to a light industry or a commerce-dominated mode; phase out inefficient equipment in industrial sectors; develop mass and fast railway transportation; and promote energy-efficient technologies at the end use. This paper transfers key messages to policy makers for designing their policy to achieve China's energy efficiency target.

08/02420 Energetic efficiency of room wall containing PCM wallboard: a full-scale experimental investigation

Kuznik, F. *et al*. *Energy and Buildings*, 2008, 40, (2), 148–156.

A wallboard new phase change material (PCM) is experimentally investigated in this paper to enhance the thermal behaviour of light weight building internal partition wall. The experiments are carried out in a full-scale test room which is completely controlled. The external temperature and radiative flux dynamically simulate a summer repetitive day. The differential test concern walls with and without PCM material under the same conditions. The PCM allows a reduction in room air temperature fluctuations, in particular when overheating occurs. A numerical modelling has been used to investigate energy storage. It was found during the experiment that 5 mm of PCM wallboard double the energy that can be stocked, and destocked. The experiments are fully described so that the results can be used for the validation of numerical models dealing with phase change materials.

08/02421 Energy conservation, expectations and uncertainty

Wirl, F. *Energy Economics*, 2008, 30, (4), 1957–1972.

This paper investigates consumers' decisions about a (single and lumpy) conservation project accounting for uncertainty and expectations (rational versus myopic). Rational expectations take into account that the profitability of individual conservation measures will affect fuel prices (here set by cartelized supply). Ignorance of this interdependence between conservation and price leads to premature investments. The interplay between demand and supply creates an incentive for a consumer cartel to initiate conservation strategically, which advances conservation compared with rational consumers but not always ahead of individually myopic decisions.

08/02422 Energy efficiency enhancement of natural rubber smoking process by flow improvement using a CFD technique

Tekasakul, P. and Promtong, M. *Applied Energy*, 2008, 85, (9), 878–895.

A non-uniform flow and large temperature variation in a natural rubber smoking-room cause an inefficient use of energy. Flow uniformity and temperature variation can be improved by using a computational fluid dynamics simulation. The effects of the size, position and number of gas supply ducts and ventilating lids which were at the inlets and the outlets of the smoking-room were investigated. The optimal rubber smoking-room of size 2.6 m × 6.2 m × 3.6 m contains 154 50 mm-diameter hot gas supply ducts, and four 0.25 × 0.25 m and four 0.25 × 0.20 m ventilating lids. The velocity distribution of this model in the rubber-hanging area was rather uniform. The average monitoring temperature of 54 positions was 62.1 °C. This model could reduce the temperature variation by a factor of three from the original room model, i.e. from 15 to 5.5 °C. In a further study, the heat input of an appropriate room model was finely adjusted to obtain a suitable temperature (60 °C) for the smoking process. It was found that an appropriate heat supply at this temperature is 11 kW. At this rate, the temperature variation is 5.3 °C. This improved model should help the rubber smoking cooperatives to achieve at least a 31.25% saving in energy.

08/02423 Energy use efficiency in the Indian manufacturing sector: an interstate analysis

Mukherjee, K. *Energy Policy*, 2008, 36, (2), 662–672.

This paper approaches the measurement of energy efficiency from a production theoretic framework and uses Data Envelopment Analysis to measure energy efficiency in the Indian manufacturing sector. Using data from the Annual Survey of Industries for the years 1998–99 through 2003–04, the study compares the energy efficiency in manufacturing across states, based on several models. The results show considerable variation in energy efficiency across states. Comparing the results across the models, it was found that the relative pricing of energy does not provide the appropriate incentives for energy conservation. A second-stage regression analysis revealed that states with a larger share of manufacturing output in energy-intensive industries have lower energy efficiency. Also, higher quality labour force associates with higher energy efficiency. Finally, the power sector reforms have not yet had any significant impact on achieving energy efficiency.

08/02424 Heat supply to low-energy buildings in district heating areas analyses of CO_2 emissions and electricity supply security

Thyholt, M. and Hestnes, A. G. *Energy and Buildings*, 2008, 40, (2), 131–139.

In several housing development projects in Norway the requirements related to the mandatory connection to district heating plants have shown to be a barrier for building low-energy residential buildings. The developers have considered the costs related to both low-energy measures and a space heating system that can utilize district heat to be too high to give the project acceptable profitability. In these projects the developers wanted to use a cheaper electric space heating system. Based on models representative for the range of the Norwegian district heating plants, calculations show that the CO_2 emissions related to heating in residential buildings with an energy standard in accordance with the new building regulations and that are connected to the district heating grid, are lower than for similar buildings with a low-energy standard and with heating based on electricity. However, in a long-term perspective the differences are marginal when considering the national annual CO_2 emissions. Similarly, increased peak power demand due to electricity-based heating may also be regarded as marginal when compared to the present maximum peak power capacity in Norway.

08/02425 Optimization of the urban building efficiency potential for mid-latitude climates using a genetic algorithm approach

Panão, M. J. N. O. *et al. Renewable Energy*, 2008, 33, (5), 887–896.

Urban planning has a considerable impact on the future energy efficiency of buildings and planners lack useful tools to support their decisions. This paper is intended to contribute to fill this gap by presenting a new method based on a genetic algorithm which is able to search for optimum urban forms in mid-latitude climates (35–50°). Here, more energy efficient urban forms are defined as those which have high building absorptance in winter and low summer building absorptance. These forms can be designed by choosing among regular tri-dimensional building geometries with fixed floor space index, which can be parameterized by adjusting the following variables: number of floors, building length ratio, grid azimuth, and aspect ratio on both directions. The results obtained show that adequate urban planning, based on the consideration of the local radiation conditions as a function of latitude, may result in significantly better building thermal performance. In particular, it is concluded that the highest latitudes are more restrictive in terms of optimal solutions: pavilions (cross-sectional square blocks) are best solutions for latitude of 50° and terraces (blocks infinite in length) are preferred for 45°. For lower latitudes, all urban forms are possible. In terms of grid angle with the cardinal direction, it is concluded that the angle should stay between −15° and +15°, except for the latitude of 50° where it can ranges from −45° to +45°. For slabs and terraces urban forms, the spacing between blocks in the north–south direction should be maximized, quantified by a building-height-to-street-width (aspect) ratio which decreases with the increase of latitude, ranging from 0.6 for a latitude of 35°, to 0.4 for a latitude of 45°. For pavilions, the north–south aspect ratio is independent of latitude and should stay close to 0.7. The pavilion is the urban form which allows for a larger number of floors.

08/02426 Optimized monthly-fixed thermostat-setting scheme for maximum energy-savings and thermal comfort in air-conditioned spaces

Al-Sanea, S. A. and Zedan, M. F. *Applied Energy*, 2008, 85, (5), 326–346.

The present study deals with energy conservation in buildings via reduction of cooling-and-heating transmission loads through walls by optimizing the indoor air-temperature settings. Maximum energy-saving and thermal-comfort are obtained for both yearly- and monthly-fixed thermostat settings. The transmission loads are calculated under the climatic conditions of Riyadh by using a dynamic heat-transfer model based on the finite-volume implicit procedure, which has been validated previously. The study utilizes a basic thermal-comfort chart where indoor air temperatures are selected inside the summer and winter comfort-zones, as a function of relative humidity, in a manner to provide the highest comfort-level while maximizing energy savings. The yearly-fixed thermostat settings range between 21.6 °C and 24.1 °C (70.9 °F and 75.4 °F), and those for the optimized monthly-fixed settings range between 20.1 °C and 26.2 °C (68.2 °F and 79.1 °F). For the yearly-fixed thermostat settings, the results show that about a 10% reduction in yearly cooling transmission load can be achieved per 1 °C increase in thermostat setting. Despite a corresponding increase of about 14% in yearly heating transmission load, a net saving in the yearly total energy cost of about 4% can still be affected per 1 °C increase in thermostat setting within the comfort zone. However, much bigger savings are achieved by utilizing an optimized monthly-fixed thermostat setting scheme developed in this study. Savings in energy cost between 26.8% and 33.6% compared with the yearly-fixed settings are obtained depending on the value of yearly-fixed setting. The corresponding reductions in peak loads compared with the yearly-fixed settings range between 13.5% and 25.6% in summer, and between 15.1% and 31.9% in winter depending on the yearly-fixed setting. These percentage savings in energy cost and reductions in peak loads are conservative since the yearly-fixed settings are themselves selected for high annual energy-savings while maintaining a high level of thermal comfort throughout the year.

08/02427 Quantifying energy savings in daylight responsive systems: the role of dimming electronic ballasts

Doulos, L. *et al. Energy and Buildings*, 2008, 40, (1), 36–50.

The application of lighting control technologies with photosensors has led to an increase in public interest. Although these technologies have been promoted during the last years their successful use in buildings has been accomplished in a small percentage of new projects. One reason is the difficulty in quantifying the energy savings and thus the subsequent payback period. Daylight responsive dimming systems consist of three basic components: photosensor, controller, and dimming unit. Electronic dimming ballast (EDB) is one substantial component of these lighting control systems which can adjust the light output due to the transferred signal from the photosensor and lighting controller. The aim of this study is to quantify energy savings among different EDBs. Eighteen commercial EDBs were selected and various sets of electrical and illuminance measurements were taken for different dimming levels, in order to develop polynomial functions between light output and consumed power. Using the measured data, a set of simulations were performed for a photosensor with an ideal cosine spatial sensitivity distribution installed in a typical office room using two control algorithms, closed loop and integral reset, trying to quantify the relative differences in energy savings.

08/02428 Using strong sustainability to optimize electricity generation fuel mixes

Bishop, J. S. K. *et al. Energy Policy*, 2008, 36, (3), 971–980.

This work represents a contribution to the field of sustainable electricity system design by using an optimization tool to specify the final mix composition, subject to the constraints of: emissions that are within the biocapacity of the region; a diverse and robust electricity supply system; and supply that at least meets current demand. The 25-country European Union (EU-25) is used as a case study. All the goals, save diversity, can be met by re-structuring the current fuel mix, thus maintaining current consumption levels. The diversity target is only met when consumption is reduced by 10–15% and the constraint on maximum material throughput is relaxed. Re-structuring the mix and reducing consumption is insufficient to achieve a sustainable EU carbon footprint. However, the solution proposed singlehandedly allows the EU to meet its Kyoto emissions target as well as its 2007 policy of a reduction of 20% in greenhouse gas emissions by 2020.

17 ENERGY CONVERSION AND RECYCLING

08/02429 Application of exhaust gas fuel reforming in diesel and homogeneous charge compression ignition (HCCI) engines fuelled with biofuels

Tsolakis, A. *et al. Energy*, 2008, 33, (3), 462–470.

This paper documents the application of exhaust gas fuel reforming of two alternative fuels, biodiesel and bioethanol, in internal combustion engines. The exhaust gas fuel reforming process is a method of on-board production of hydrogen-rich gas by catalytic reaction of fuel and engine exhaust gas. The benefits of exhaust gas fuel reforming have been demonstrated by adding simulated reformed gas to a diesel engine fuelled by a mixture of 50% ultra low sulfur diesel and 50% rapeseed methyl ester as well as to a homogeneous charge compression ignition (HCCI) engine fuelled by bioethanol. In the case of the biodiesel fuelled engine, a reduction of NO_x emissions was achieved without considerable smoke increase. In the case of the bioethanol fuelled HCCI engine, the engine tolerance to exhaust gas recirculation was extended and hence the typically high pressure rise rates of HCCI engines, associated with intense combustion noise, were reduced.

08/02430 Bio hydrogen production from kitchen waste

Jayalakshmi, S. *et al. International Journal of Environment and Waste Management*, 2008, 2, (1–2), 75–83.

The hydrogen-producing organisms such as *Escherichia coli*, *Enterobacter cloacae*, *Hafnia alvei*, *Citrobacter freundii*, *Serratia marcescens* and *Clostridium acetobutylicum* strains were isolated from the sludge of biogas plant. The hydrogen producing efficiency of isolated organisms from kitchen waste were examined under anaerobic conditions. Lab scale studies were conducted under controlled and ambient temperature conditions, both in the presence and absence of bacteria. Maximum hydrogen production was found in the experiment with the *C. acetobutylicum*. The hydrogen production in the reactor with

C. acetobutylicum was estimated as 179.59 mL/kg TS/day in ambient temperature condition and 185.29 mL/kg TS/day in controlled temperature condition.

08/02431 CFD modelling of black liquor gasification: identification of important model parameters

Marklund, M. *et al. Fuel*, 2007, 86, (12–13), 1918–1926.

Pressurized high temperature black liquor gasification has the potential to significantly improve the efficiency of energy and chemical recovery in the pulping industry and to enable new processes, e.g. production of renewable automotive fuels from the formed synthesis gas. However, the current process is still considered as novel and the interest in validated computer models for scale-up and process optimization is large. In this paper a sensitivity analysis on the four most important model parameters in the pre-processing 'droplet composition model' for a proposed CFD model has been performed. It was shown that careful measurements of the amount of sulfur released to the gas phase as H_2S during devolatilization and the concentration ratio of Na_2S and Na_2SO_4 in the black liquor char under real process conditions are of great importance for calibration of the model.

08/02432 Characterisation of slow pyrolysis products from segregated wastes for energy production

Phan, A. N. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 65–71.

The role of pyrolysis is important in the thermal processing of municipal solid wastes, since it decomposes wastes into three types of intermediate products to be collected as fuel feedstock or to be gasified/combusted. In this study, the main products from slow pyrolysis of key segregated waste materials were characterized for mass yield, energy content, elemental composition and chemical compounds. About 200 g of waste wood, cardboard or textile residues were pyrolysed in a small packed bed reactor at a final temperature ranging from 350 to 700 °C with a slow heating rate. The char contained about 38–55% of the energy content in the raw material. The difference in the properties of char between the materials was mainly due to the incombustible fraction that remained in the solid product. The pyrolysis liquids had a gross calorific value of about 10–12 MJ/kg, representing about 20–30% of the energy content in the raw material. The liquids consisted mainly of water and oxygenated compounds such as furans, derivative carboxylic acids and anhydrosugars. Over two thirds of the gases produced were CO and CO_2 with increased proportions of CH_4 and H_2 at high temperatures above 500 °C.

08/02433 Combustion characteristics of waste-oil produced biodiesel/diesel fuel blends

Lin, Y.-F. *et al. Fuel*, 2007, 86, (12–13), 1772–1780.

In this study, wasted cooking oil from restaurants was used to produce neat (pure) biodiesel through transesterification, and this converted biodiesel was then used to prepare biodiesel/diesel blends. The goal of this study was to compare the trace formation from the exhaust tail gas of a diesel engine when operated using the different fuel type: neat biodiesel, biodiesel/diesel blends, and normal diesel fuels. B20 produced the lowest CO concentration for all engine speeds. B50 produced higher CO_2 than other fuels for all engine speeds, except at 2000 rpm where B20 gave the highest. The biodiesel and biodiesel/diesel blend fuels produced higher NO_x for various engine speeds as expected. SO_2 formation not only showed an increasing trend with increased engine speed but also showed an increasing trend as the percentage of diesel increased in the fuels. Among the collected data, the PM concentrations from B100 engines were higher than from other fuelled engines for the tested engine speed and most biodiesel-contained fuels produced higher PM than the pure diesel fuel did. Overall, It may be concluded that B20 and B50 are the optimum fuel blends. The species of trace formation in the biodiesel-contained fuelled engine exhaust were mainly C_nH_{2n+2}, DEP, and DPS. For the B100, B80, B50, and D fuelled engines, $C_{15}H_{32}$ was the dominant species for all engine speeds, while squalene ($C_{30}H_{50}$) was the dominant for B20. DEP was only observed in the B100, B80, and B50 fuelled engines in this study. The D fuelled engine showed a higher DPS production for engine speeds higher than 1200 rpm.

08/02434 Conversion of asphalt into distillate products

Shakirullah, M. *et al. Energy Conversion and Management*, 2008, 49, (1), 107–112.

This paper reports the conversion of asphalt in a micro-autoclave under an inert atmosphere of nitrogen to lighter products. The influence of temperature, contact time and some catalysts, i.e. clay type; UTIMAC, HZSM-5 and sodium silicate, acidic type; phosphotungstic acid, oxide type; ammonium hepta molybdate, silica gel, nickel oxide and alumina powder, chloride type; stannous chloride and aluminum chloride and modifiers like methyl iodide and coal, on the yield of liquid and gas products was studied. A marked effect of temperature on the yield of liquid as well as gas products was observed. Employment of clay type catalysts was found to be beneficial in term of yields of liquid products. Among the catalysts used; UTIMAC clay caused the maximum conversion to desired products. The other catalysts caused a decline in the yield of desired products because of coke formation due to condensation reactions catalysed by these catalysts. The effect of concentration in the case of clay as catalyst was also studied, and synergistic effects were observed in terms of desired product yield. The study will be helpful in planning asphalt conversion processes into light oil fractions.

08/02435 Conversion of recycled paper sludge to ethanol by SHF and SSF using *Pichia stipitis*

Marques, S. *et al. Biomass and Bioenergy*, 2008, 32, (5), 400–406.

The purpose of the present work was to evaluate the possibility of converting recycled paper sludge (RPS), an industrial residue stream with strong environmental impact, into valuable products. The approach used was based on the enzymatic conversion of major sludge components (cellulose and xylan) and the simultaneous (simultaneous saccharification and fermentation – SSF) or sequential (separate hydrolysis and fermentation – SHF) fermentation of the resulting sugars to ethanol. In the enzymatic hydrolysis step using Celluclast® 1.5 L supplemented with Novozym® 188, a degree of saccharification of 100% was achieved. In relation to ethanol production using the yeast *Pichia stipitis* CBS 5773, SHF and SSF process efficiencies were compared. A slightly higher conversion yield was attained on SHF, corresponding to an ethanol concentration of 19.6 $g\,L^{-1}$, but 179 h were needed. The SSF process was completed after 48 h of incubation allowing the production of 18.6 $g\,L^{-1}$ of ethanol from 178.6 $g\,L^{-1}$ of dried RPS, corresponding to an overall conversion yield of 51% of the available carbohydrates on the initial substrate. These results demonstrate that the biological conversion of sludge to ethanol is efficient even with no pre-treatment or substrate supplementation.

08/02436 Designs of anaerobic digesters for producing biogas from municipal solid-waste

Igoni, A. H. *et al. Applied Energy*, 2008, 85, (6), 430–438.

The production of biogas is of growing interest as fossil-fuel reserves decline. However, there exists a dearth of literature on the design considerations that would lead to process optimization in the development of anaerobic digesters aimed at creating useful commodities from the ever-abundant municipal solid-waste. Consequently, this paper provides a synthesis of the key issues and analyses concerning the design of a high-performance anaerobic digester.

08/02437 Development of a new pH-swing CO_2 mineralization process with a recyclable reaction solution

Kodama, S. *et al. Energy*, 2008, 33, (5), 776–784.

A new CO_2 mineral sequestration process using the pH swing of a weak base–strong acid solution was proposed. In this process, an alkaline-earth metal was extracted selectively from silicate waste material, such as steelmaking slag or waste concrete, in an acidic condition using a weak base–strong acid solution. The reacted solution containing alkaline-earth metal ions and a weak-base, behaves as a CO_2 absorbent. The acidic extraction solution was regenerated from the basic absorbent solution by precipitating the alkaline-earth metal with CO_2 as the carbonate. The thermodynamic analysis of this process shows that a series of reactions proceeds spontaneously and the overall reaction is exothermic. The feasibility of the proposed process was confirmed using steelmaking slag as a silicate material and ammonium chloride solution as a weak base–strong acid solution. It was confirmed that this series of reaction proceeds successfully under mild conditions. Calcium ions were extracted selectively from steelmaking slag using an ammonium chloride solution, and the reacted solution absorbed CO_2 followed by the precipitation of $CaCO_3$ at 80 °C. On the basis of these experimental analyses, the energy consumption of the proposed process was roughly estimated as 300 kWh/ton-CO_2.

08/02438 Effects of exhaust gas recirculation (EGR) on combustion and emissions during cold start of direct injection (DI) diesel engine

Peng, H. *et al. Energy*, 2008, 33, (3), 471–479.

Through experiments conducted on a single cylinder direct injection diesel engine, effects of exhaust gas recirculatoin (EGR) on combustion and emission during cold start were investigated. Combustion of first firing cycle can be promoted significantly by introducing EGR. In experiments, when partially closed choking valve and partially or fully opened EGR valve, peak cylinder pressure of first firing cycle was about 45% higher than that under normal condition without EGR, and the start of combustion was also much earlier. EGR also had effects on combustion stability. In the case, which kept 50% or 100% opening of EGR valve and kept 100% opening of choking valve, more stable combustion process was achieved when common rail pressure decreased during cold start. However, excessive amount of EGR led to extreme unstable combustion and even misfiring. Opacity and NO emissions were also analysed in detail. In the case with maximum EGR, the lowest average opacity, which was less than 4%, was achieved during initial several firing cycles of cold start. But in the later phase, excessive amount of EGR led to a great deal of white smoke emission. NO emission during initial phase of cold start is mainly affected by increase in fuel amount of injection. When combustion became stable gradually, EGR showed significant effect on NO reduction.

08/02439 Ethanol production from bread residues

Ebrahimi, F. *et al. Biomass and Bioenergy*, 2008, 32, (4), 333–337.

Bread residues were converted into a suitable fermentation feed via a two-step starch hydrolysis using amylolytic enzymes. Wheat flour hydrolysis was also carried out at the same conditions for comparison. For the first stage, namely liquefaction, effects of temperature (50–85 °C) and substrate concentration (20% and 35%) were investigated. The 3-h liquefaction of the 20% bread suspension made 70% of initial dry matter soluble regardless of the temperature. The liquefaction of the 35% bread suspension had to be carried out by a fed-batch method due to the pasty behaviour of the suspension. It resulted in a 65% dissolution of the suspended bread at 85 °C. Saccharification of the latter product led to a fermentation feedstock having a dextrose equivalent of more than 95 and almost 80% dissolution of the initial dry matter. The prepared feedstock was then cultivated using *Saccharomyces cerevisiae*, which resulted in an overall yield of 350 g ethanol per kg of initial bread dry matter. Staling of the bread for a week had no effect on liquefaction, saccharification and ethanol yield.

08/02440 Improving the efficiency of pyroelectric conversion

Kouchachvili, L. and Ikura, M. *International Journal of Energy Research*, 2008, 32, (4), 328–335.

Pyroelectric conversion utilizes low-grade waste heat as a heat source, and thus produces clean energy. Low-grade heat is abundant in the various industries and it is practically free. It can be converted to high-voltage electricity by pyroelectric conversion. The pyroelectric converter uses copolymer of poly-vinylidence fluoride with trifluoroethylene [60/40% P(VDF–TrFE)]. Previously, a substantial power loss was encountered due to internal leakage at high temperature and voltage. In order to increase the power output, the effect of polymer purification was examined using solvent extraction. The authors compared the electrical properties of purified copolymers with those of 'as-received' copolymers. Although only 0.4 wt% of the copolymer was removed by solvent extraction, the electrical resistivity of purified copolymer was 35% higher than that of the 'as-received' copolymer. It was also observed that thin films produced using purified copolymer were able to withstand a 50% higher electric field before they were ruined by the electrical short circuit. Subsequently, pyroelectric conversion was conducted using 25 μm thick 60–40% P(VF$_2$–TrFE) copolymer films. Copolymer purification resulted in a three-fold increase in net power output. Net power output per unit volume of the 'as-received' copolymer was 95 J L^{-1} but it increased to 279 J L^{-1} for purified copolymer.

08/02441 Optimum length of finned pipe for waste heat recovery

Söylemez, M. S. *Energy Conversion and Management*, 2008, 49, (1), 96–100.

A thermoeconomic feasibility analysis is presented yielding a simple algebraic optimization formula for estimating the optimum length of a finned pipe that is used for waste heat recovery. A simple economic optimization method is used in the present study by combining it with an integrated overall heat balance method based on fin effectiveness for calculating the maximum savings from a waste heat recovery system.

08/02442 Semi-continuous co-digestion of solid slaughterhouse waste, manure, and fruit and vegetable waste

Alvarez, R. *et al. Renewable Energy*, 2008, 33, (4), 726–734.

The potential of semi-continuous mesophilic anaerobic digestion for the treatment of solid slaughterhouse waste, fruit-vegetable wastes, and manure in a co-digestion process has been experimentally evaluated. A study was made at laboratory scale using four 2 L reactors working semi-continuously at 35 °C. The effect of the organic loading rate was initially examined (using equal proportion of the three components on a volatile solids, VS, basis). Anaerobic co-digestion with OLRs in the range 0.3–1.3 kg VS m^{-3} d^{-1} resulted in methane yields of 0.3 kg VS m^{-3} d^{-1} VS added, with a methane content in the biogas of 54–56%. However, at a further increased loading, the biogas production decreased and there was a reduction in the methane yield indicating organic overload or insufficient buffering capacity in the digester. In the second part of the investigation, co-digestion was studied in a mixture experiment using 10 different feed compositions. The digestion of mixed substrates was in all cases better than that of the pure substrates, with the exception of the mixture of equal amounts of (VS/VS) solid cattle–swine slaughterhouse waste with fruit and vegetable waste. For all other mixtures, the steady-state biogas production for the mixture was in the range 1.1–1.6 L d^{-1}, with a methane content of 50–57% after 60 days of operation. The methane yields were in the range 0.27–0.35 m^3 kg^{-1} VS added and VS reductions of more than 50% and up to 67% were obtained.